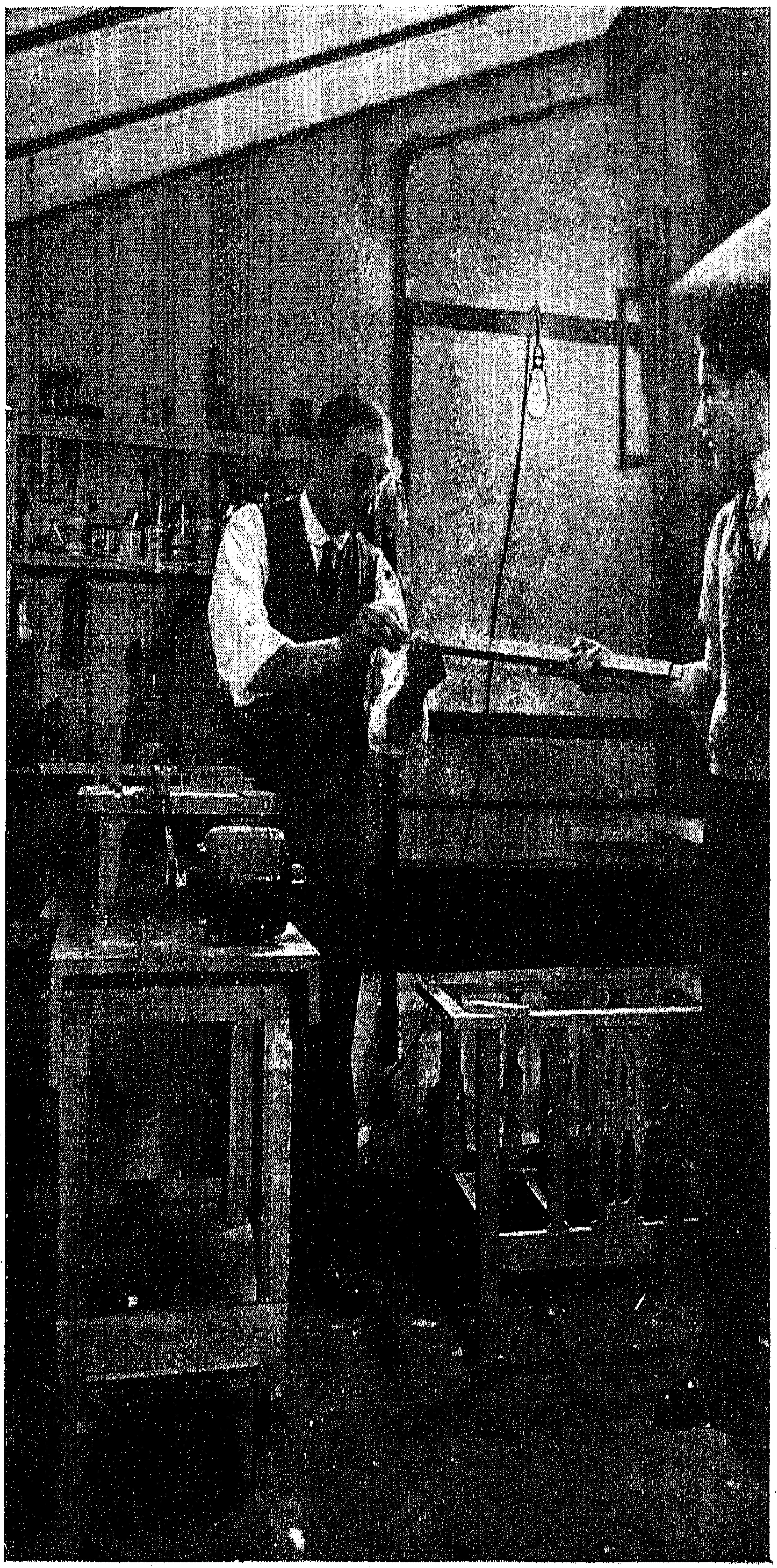
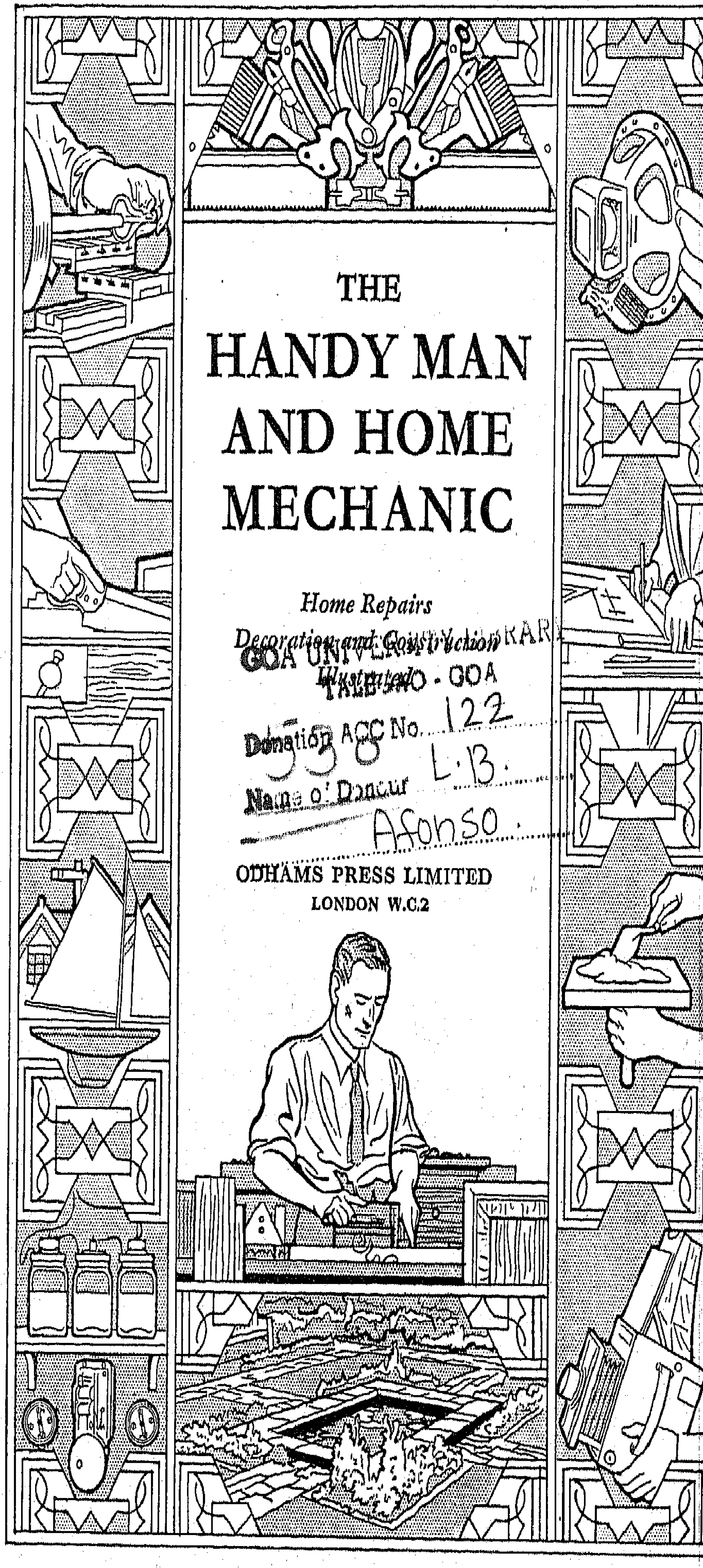


IN THE HOME WORKSHOP



THE
HANDY MAN AND HOME MECHANIC

Home Repairs
Decoration and Construction
Illustrated

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INTRODUCTION

THE Dictionary defines a handyman as "A man of all work." In these specialist days, the handyman has almost disappeared from business, but he lives on in the home in greater glory than ever.

There is something unusually satisfying—something that appeals to the fundamental instincts of husbandry—for a man to be a real handy man in his own home.

To the average man, there are few pleasures in life comparable to that of doing a job himself in and about his own home.

Was there ever a bookcase that gave a fraction of the satisfaction as the one fashioned by your own hands? Was ever paint more pleasing—distempering more delightful—a crazy path more happily laid, a greenhouse or a shed more worthily made—than that on which you have lavished your own care and time and skill? To be a craftsman—to create, with brain and hands, some of the necessities of life—to furnish one's home with comforts, gives a man a feeling of solid competency and achievement.

Only those who have experienced the thrill of making things know what the man misses to whom such things as wood and nails and hammers and saws and paint and varnish and wire and metal are things in a world apart. To the handy man, they are the stuff of which a thousand and one things are made.

Apart from the pleasure that being a craftsman brings, there is the business side. It makes a big difference to your pocket to be able to turn and do things for yourself—in the course of years it represents a very considerable economy and in these days that means a lot.

To you, whether you are a seasoned craftsman or just a beginner, this book is dedicated. It is written by practical men for practical men in plain and simple language that all can understand. To those who are already experienced we believe that in the pages of this book there may be found much that is useful. Even if there are jobs here you have done without instructions, there still remain the tips and wrinkles gained by long experience to ease the work and make difficult parts appear simple.

In any case, the wider a man's experience, the more anxious is he, as a rule, to extend his knowledge, and there is much in these chapters that follow that will be found of interest even to old hands at the game.

To those who are beginners, this book is intended to be *really* helpful. While its scope is wide, it assumes little previous knowledge—while it covers the activities of the handy man in the home from A to Z, it does not deal with the XYZ before it explains the ABC.

If you have hands that will obey your brain and a brain that will follow this book, you will have no difficulty. For here are instructions for the perfect completion of almost any household job. The simple writing of these instructions is supported by hundreds of plans, drawings and photographs that doubly clarify the problem in hand. And added to that is a series of beautifully printed working drawings, seven of which are on a large scale and separated from the book for easy and constant reference. The "Handy Man and Home Mechanic" is the epitome of experience. You are shown not only how to do a particular job, but how to do it in the easiest and quickest way, and the cheapest manner consistent with good results.

This book will fill your leisure hours with pleasure and profit. Aimless leisure is unknown to the handy man. He has a necessary job for every minute—he has a lifetime hobby inherited from time immemorial from his forefathers—that of making and doing *real* things.

Remember that the final charm of being an efficient handy man is that you can produce things that money cannot buy in the ordinary way. You may have an alcove in which shelves and a cupboard would look admirable, but no shop sells exactly the size and the shape of fixture you want. In making it yourself, you not only have a lot of pleasure, but you get precisely what you require. Unless you order things to be specially made for you —and the cost of that is sometimes more than you can afford—there is no other way in which you can achieve it.

THE EDITOR

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With this Volume is given an envelope containing seven large working drawings.

WOODWORK

TIMBER

WOODWORKING, from the handyman's point of view, includes carpentry and joinery, and cabinet-making. The former applies more or less to the erection of sheds, cupboards, fitting shelves and similar work, and refers more to the working of wood into useful objects rather than the beautiful; while the latter calls for workmanship that is a good deal more artistic and exacting. Having chosen woodworking as a means of occupying your spare time, the initial step is to learn something of the nature and peculiarities of the material upon which you are going to work. Unless you have some idea of the properties of the commoner varieties of timber, you will be at a loss to know the best kind of material to use for the work you wish to undertake. Thus, some woods, such as yellow pine, can only be used in dry situations, while others, such as oak and teak, can be used for outside purposes, exposed to all weathers. Some woods, especially yellow deal, can be used for either, but where it is used for outside purposes it should be carefully painted. Again, some woods can be finished to produce a brilliant polish, a typical example being mahogany; but others, such as teak, will not take polish.

Although there are dozens of different kinds of woods used by the professional craftsman, it would be sheer waste of time to go into details about wood you are not likely to use.

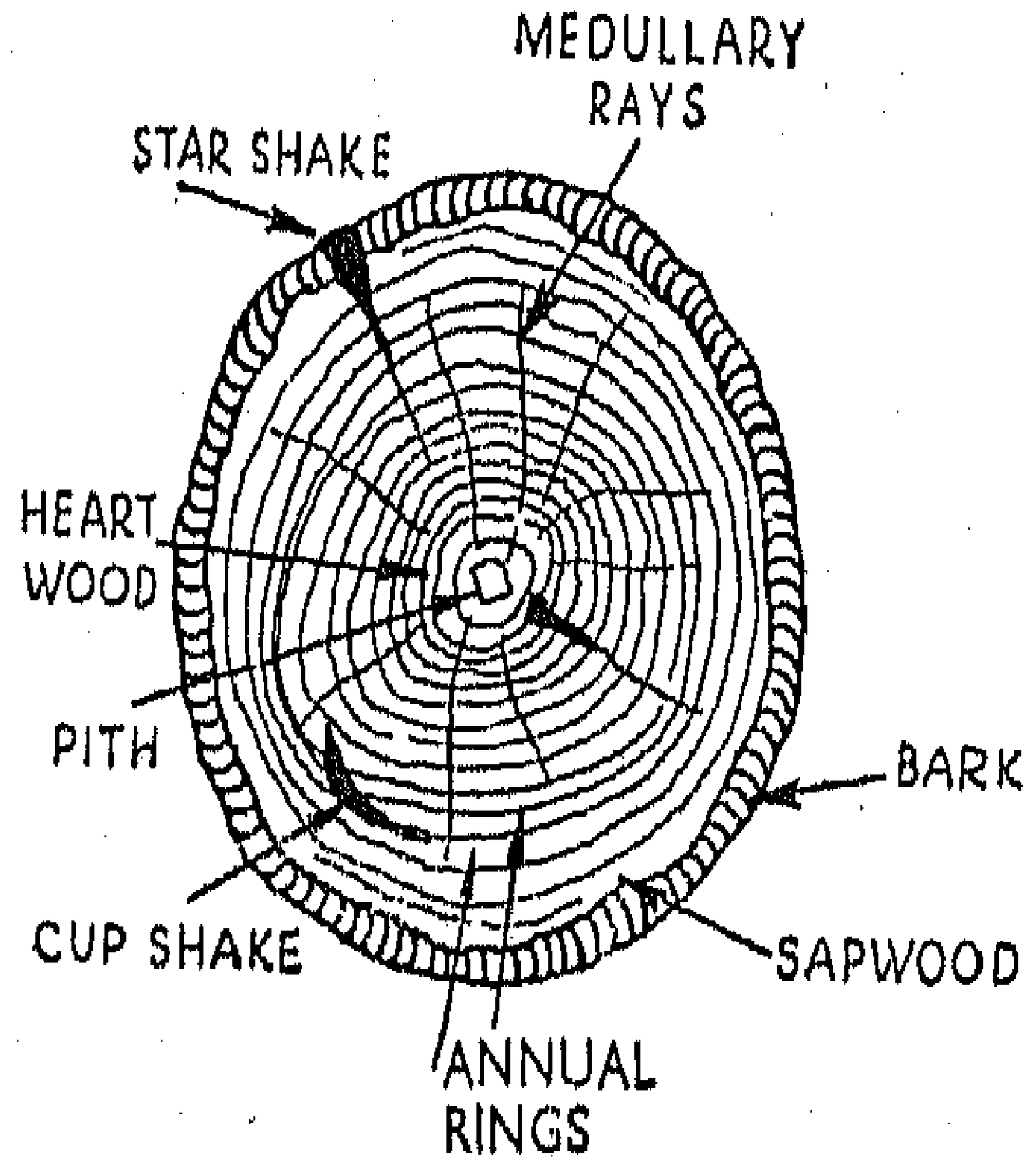


Fig. 1

The descriptions given in the following paragraphs are intended to outline the characteristics of the commoner kinds of timber and the uses to which they are generally put.

Woods are usually classified under two headings, soft and hard, although some softwoods are really hard and some hardwoods soft.

Softwoods are obtained from coniferous trees—that is, trees having evergreen, needle-shaped leaves, the timber of which is more or less resinous. Hardwood is produced mainly from non-coniferous trees, whose broad leaves are shed annually, as the oak.

The commonest softwoods used principally in carpentry and joinery are pine and spruce. The hard variety include oak, walnut, mahogany and American whitewood, which, although soft in texture is usually known as a hardwood.

All timber used in constructional work is cut from "outward growing" (exogenous) trees. If a cross-section of a tree (as illustrated in Fig. 1) is examined, it will be noticed that numerous concentric rings surround the pith. These rings, called "annual rings," are formed at the rate of one a year and provide a ready means of roughly estimating the age of the tree. This statement, however, does not apply to all timber, as in certain tropical trees there may be more than one ring per annum.

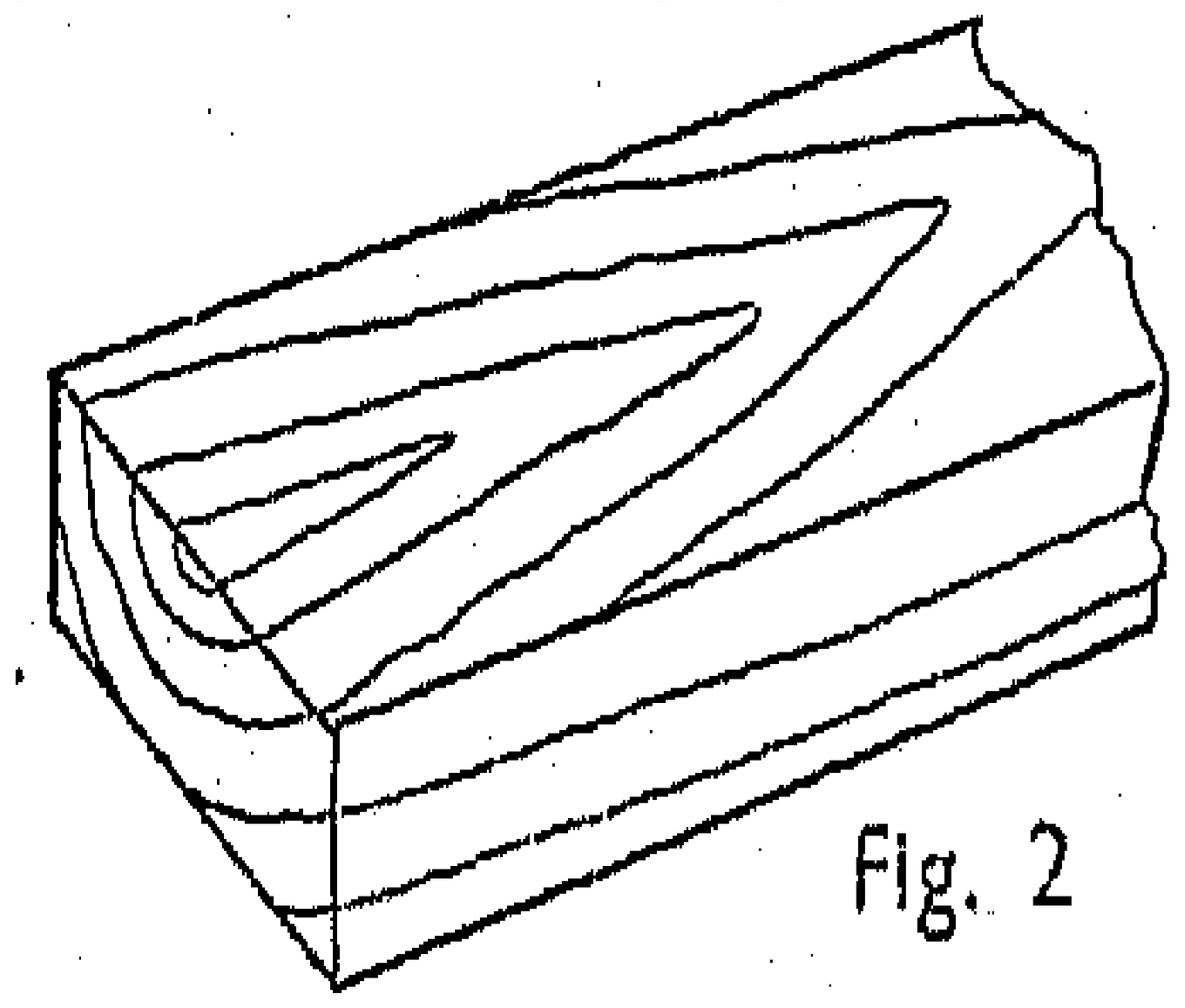


Fig. 2

The lines seen radiating from the pith are called "medullary rays," and, when suitably cut, give the beautiful figuring of the wood.

During growth the inner parts of the tree fill up somewhat and harden and form what is known as "heartwood." That portion of the timber which lies just beneath the bark is called "sapwood."

The following points should be noted when selecting timber: Always obtain well-seasoned wood that is straight in the grain, of uniform colour, smells sweet, and has its annual rings close together.

If the plank comes from the centre of the tree you may get a strip of pithwood that will lift from the surface (as illustrated in Fig. 2). On the other hand, if a greenish-blue colour appears in softwood it usually indicates that the plank contains sapwood, which is not only weaker than other parts, but soon decays. The sapwood of most dark-coloured hardwoods is greyish-white in tint.

Fig. 3 shows another defect known as "waney edge," where what should be square corners become rounded. It is caused by the too economical cutting from the log; in fact, in some cases some of the bark appears on the waney edges.

"Heart shakes" and "star shakes" (Fig. 1) are also defects associated with timber. The former is usually found in wood cut from old trees, and the latter is generally caused by bad seasoning.

Here is a list of the most commonly used softwoods:

Yellow Deal.—Deal refers to the northern pine grown in Norway and Sweden and the Baltic region. It is sometimes referred to as Scotch fir and is the wood most used by the amateur woodworker. Timber obtained from this tree is known in the trade as yellow deal, but in the north of England it is called red deal. It is light in weight, fairly tough and easily worked; and when it is well seasoned can be relied upon. The advantage of using this wood, especially of the better quality known as "Archangel first," is that it is cheap, straight-grained, more or less free from knots, and can be planed to produce a smooth surface. It is suitable for all kinds of joinery work, such as doors, window-frames, cupboards, kitchen tables, etc.

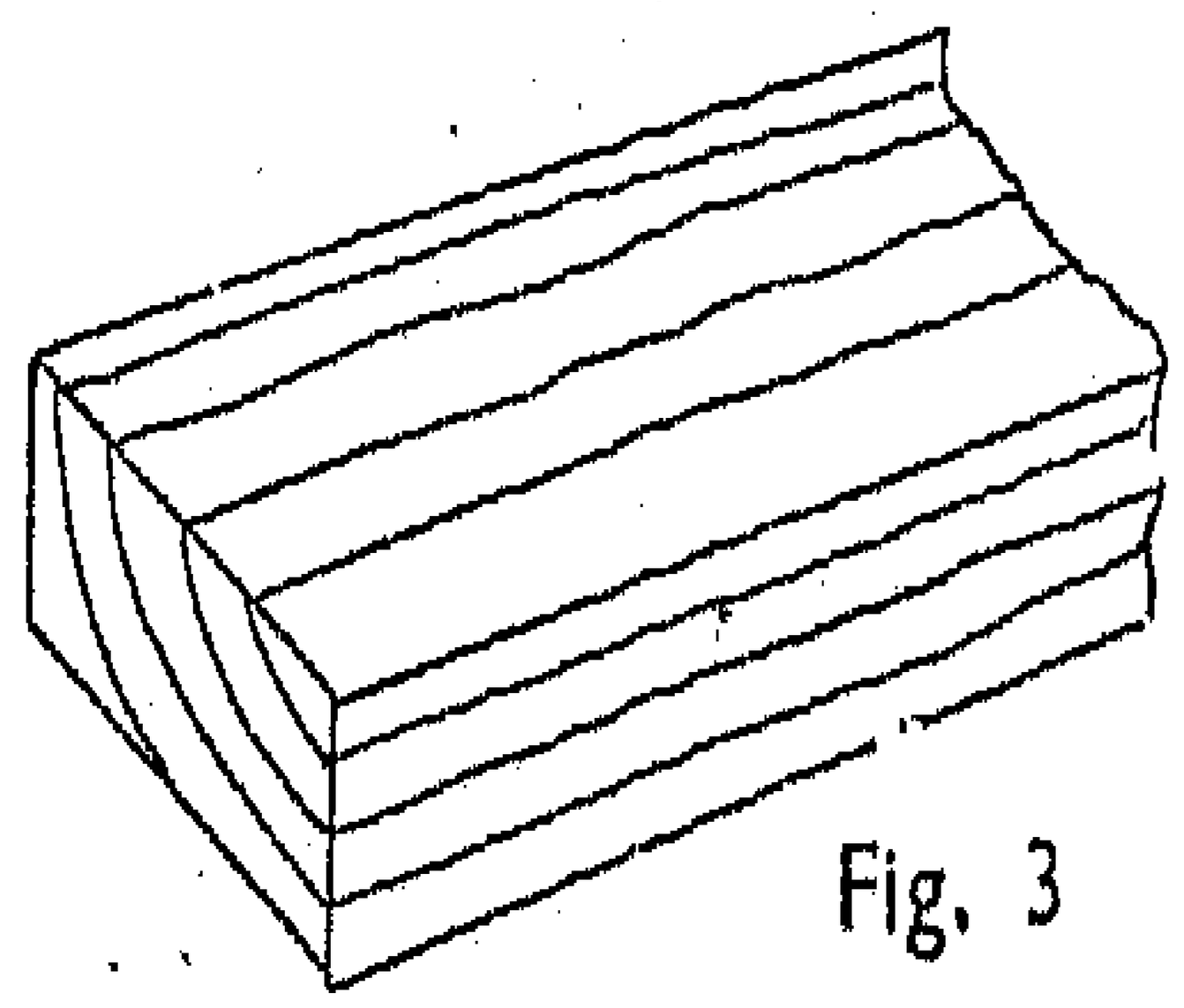


Fig. 3

White Deal.—Wood obtained from the spruce fir, grown in Norway, and generally known as white deal or common spruce, is unsuitable for joinery work because it warps and splits easily, is somewhat difficult to work, and generally has a large number of large, loose knots. For box-making and shelves, and similar common work, however, it answers the purpose very well and is cheaper than yellow deal.

Yellow Pine.—Yellow pine must not be confused with yellow deal, as it is lighter in weight, softer and less durable. It is a product of North America. The wood is almost entirely free from knots, straight-grained, and does not shrink or warp to any appreciable extent. It is unsuitable for outdoor work or for use in damp situations, but is durable when used in dry places. Yellow pine is easily worked, and is an excellent wood for joinery, mouldings, and work which necessitates the use of wide boards, such as panels, as it can be obtained in widths up to three feet. The disadvantage of this wood is its comparatively high cost.

Pitch Pine.—This wood is extremely strong, heavy and straight-grained. Its colour varies from a dark yellow to a light reddish-brown. It is very durable, on account of the large amount of resin present, which also makes it very difficult to plane and paint. It is used principally in the form of blocks for making floors, thresholds, treads of staircases and other indoor work that is subject to wear.

The following is a list of commonly used hardwoods:

Ash.—Ash is a whitish-coloured, close-grained wood. It is tough and springy and is used for cart shafts, tool handles, gates and furniture. It is durable if used in dry situations, but is unsuitable for ordinary constructional work.

Beech.—This wood is of a yellowish-white colour, very hard, and has a close and compact grain. Owing to this feature it is used largely for wood-turning. Beech is also favoured a great deal for making the wooden parts of tools, such as mallet heads, stocks of planes, etc. It is also employed for making chairs and other articles where a hard, durable material is required.

Box.—Boxwood is exceedingly hard, has a very even, close and compact grain and takes a fine polish. It is a very useful wood for the turner, and should you at any time acquire a lathe you will find it very useful for turning tool handles, chessmen, wooden chucks, etc. It is rarely obtained over about 4 in. in diameter.

Elm.—Elm is a very difficult wood to work as it is very tough and cross-grained. It warps badly, but takes nails better than any other wood. Elm is an excellent wood to use in damp situations and under water. It is for this reason that wheel-barrows, agricultural tools, stable fittings and numerous other articles subjected to dampness are made from it.

Mahogany.—This wood, of which there are several varieties, is the ideal one for the amateur woodworker who specialises in cabinet-making. That known as "Honduras" or baywood, from Central America, is inferior to "Spanish" from Cuba and Jamaica. The former is pinkish in colour. In the best quality it is easily worked, but the inferior kind sometimes planes up rough and spongy. It can be obtained in boards up to 5 ft. in width and, as it is cheaper than Spanish, it is more widely used. Its use is confined principally to cabinet-making and furniture. Spanish mahogany is of a deep red-brown colour and can be usually distinguished by a whitish, chalky substance which fills the pores. It is beautifully marked, takes glue better than any other wood, is remarkably free from knots and other defects, and has less tendency to warp than any other wood. It also takes a brilliant polish. Spanish mahogany is used for high-class furniture or cabinet making, and is cut into sheets for veneering inferior kinds of wood.

The amateur woodworker will find it a great advantage to make all appliances such as straight-edges, winding strips, etc., from this excellent and reliable wood, for by so doing he will not have to worry himself continuously over possible inexactitudes in his work due to untrustworthy tools.

Oak.—This wood is generally associated with England's might of the past. Our old manor houses, farmhouses and even cottages boast of their oak beams that stand and smoulder even in a fire where steel girders crumple up. There are a vast number of species of oak, but all have the same main characteristics and vary in colour from light brown to dark brown. It is a close, compact, straight-, but more or less broken-grained wood; very hard and extremely durable and weather-resisting, though having a tendency to twist and warp. Oak is extremely useful for building construction, fence-making, and general outdoor work. It is also very much more used in these days than formerly for cabinet work, in the form of "wainscoat" or "quartered" oak. In the former, the tree trunk is run through the frame-saw set to cut the log right through to the thicknesses required (as shown in Fig. 4), but for beautiful effects an attempt is made to cut the log to show the grain-mark or figure.

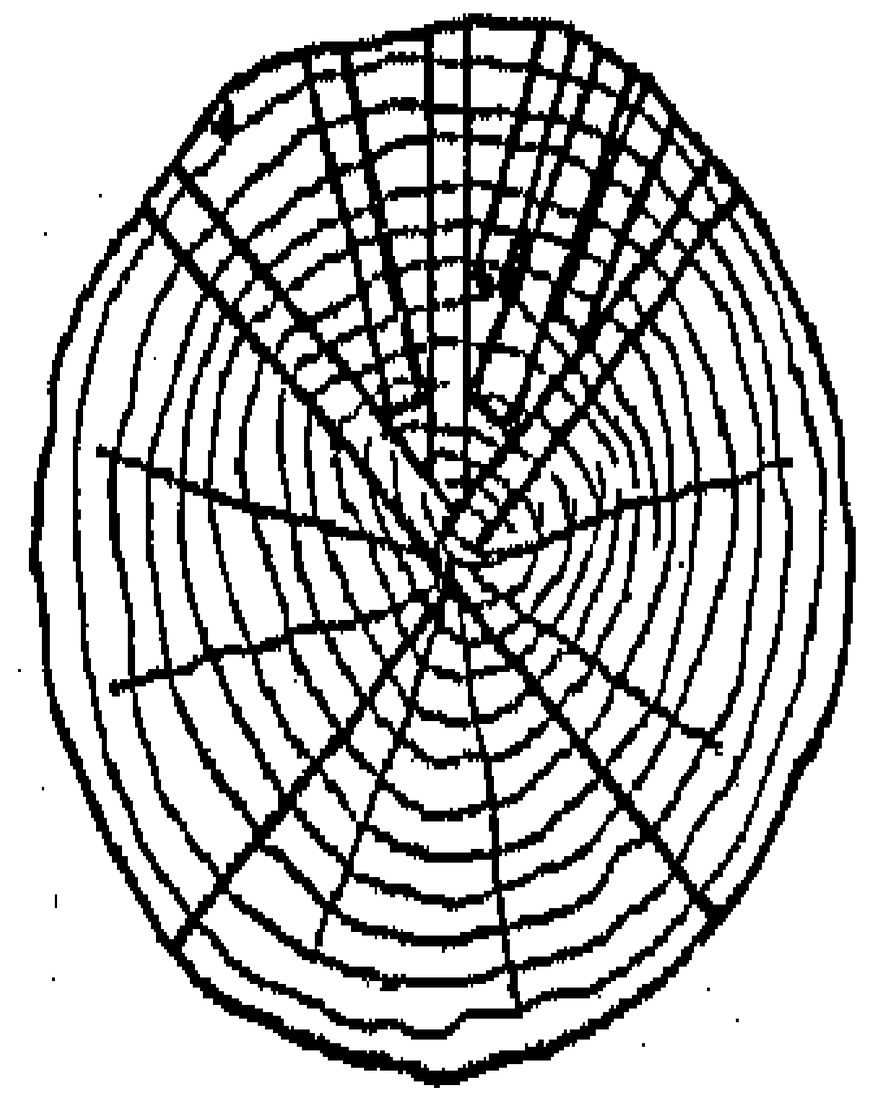


Fig. 4

Teak.—This wood is sometimes called "Indian Oak" as it resembles oak in grain and colour and has an even texture. It is easy to work when new, but more difficult when thoroughly seasoned. It is non-inflammable, does not shrink or warp to any great extent, and weathers well. Best quality teak is imported from Burma and Siam, while an inferior quality comes from Java. Teak does not take a polish but looks well when oiled. It is very durable, even when subjected to alternate wet and dry, and is therefore an excellent wood for outside work. It resists insects and does not corrode nails and screws, due to its natural oil. Teak is employed largely in shipbuilding, building construction, superior joinery, and for making the outside containers of electrical storage batteries.

Walnut.—This is another useful but expensive wood much used in these days for cabinet work. Its scarcity makes it inapplicable for general constructional work; but on account of its beauty and other good qualities it should appeal to the amateur craftsman who wishes to make something artistic to match existing furniture. It is tough and hard, easily worked, and takes a good polish. The American variety is darker and straighter in grain than English or Italian, the former having a grey-brown colour and the latter a dark, purplish tint.

Satin Walnut is a product of the United States of America. It is close-grained, easy to work and takes a good polish. The colour is a light reddish-brown, and the wood is obtainable in large widths. Satin walnut is exceedingly liable to warp and twist. The amateur should, therefore, think twice when planning to make anything with this wood. It was once used extensively for making cheap furniture, but seems to have lost favour during the last few years.

Plywood.—An extremely useful form of wood for both amateur and professional, known as plywood, has come into favour during the past few years. Briefly stated, plywood consists of a

number of thin layers of wood so placed that the grain of each layer is across the grain of its neighbour. Each layer is glued, and the whole subjected to enormous pressure, resulting in a very tough board. It will be understood that by making the outside layers of more expensive woods and the inside laminations of a common variety it is possible to get practically the same result at a very much reduced cost compared with that of solid wood.

Plywood is valuable for making panels and work of a similar nature. It can be obtained in various sized sheets up to 60 in. by 48 in. and from 3 mm. to about 1 in. in thickness, faced with oak, mahogany and a number of other hardwoods.

Pulpwood.—The amateur will also find pulpwood boards extremely useful for numerous purposes, such as panels for doors, panelling a room, making partitions, etc. It is composed of wood-pulp and an adhesive which is pressed into large sheets. Some kinds are so heavily and closely pressed and treated that they become practically impervious to damp, and the texture is so fine and close that it can even be planed at the edge, provided a sharp tool is used. It saws readily and may also be cut with a sharp knife, while nails can be driven into it easily.

Pulpwood boards are sold in sheets of 6 ft. to 16 ft. in length, and 3 ft. and 4 ft. in width. These useful boards are sold under various trade names.

SELECTION AND USE OF TIMBER

THE characteristics of various kinds of wood used by the amateur having been dealt with, a few general remarks on the selection and the proper use of timber may be acceptable to those readers who have had little or no experience in this direction.

The old saying that "a little learning is a dangerous thing" does not apply in this case, as a little knowledge on this subject may be the means of a considerable saving in the cost of material.

The word "timber" generally refers to that portion of the felled tree which when deprived of its limbs forms a "log." The logs may be sawn squarely to form a "baulk," which may vary in size from 12 in. by 12 in. to 18 in. by 18 in. Logs are also then subdivided into "deals," "planks," "scantlings," "battens," etc., the sizes of which vary considerably.

For instance, a deal is the size of a piece of timber 9 in. wide, whose thickness varies from 2½ in. to 4½ in.; while a plank measures anything above 15 in. wide and over 3½ in. in thickness.

A batten is narrower than a deal, and may measure anything from 4½ in. wide and from ¾ in. to 3 in. in thickness.

Timber cut to a thickness of less than 2 in. and to any width from 6 in. upwards is called a "board."

The term "quartering" is applied to timber of square section, and varies in size from 2 in. by 2 in. to 6 in. by 6 in.

Scantlings are pieces of timber with sides varying from 2 in. to 5 in. and averaging about 2 in. in thickness.

Sawn softwood boards can be usually obtained in standard widths of 6, 7, 8, 9 and 11 in. in the following thicknesses: ⅝, ¾, 1, 1¼ and 1½ in. and up to about 24 ft. in length. These sizes may be a trifle smaller when purchased at the timber-yard as they may have shrunk a little during the process of seasoning.

When ordering softwood it is usual to specify either "sawn" or "prepared" stuff. The former means that the faces and edges are more or less rough and in the same condition as it left the saw; while the latter has its sides and edges finished by a planing machine. Thus, in ordering, say, a 12 ft. length of 2 by 3, ordinary sawn material is implied, and you will possibly receive a piece of wood whose sectional dimensions are of full size. On the other hand, these measurements may be smaller, especially if the timber-yard sawyer has cut two pieces of the material from a 2 in. by 6 in. batten. One piece measures a full 2 in. by 3 in., but the other piece may be smaller, due to the thickness and set of the circular saw.

When a length of 2 in. by 3 in. prepared stuff is asked for, you will receive a length whose sectional dimensions will measure only 1¾ in. by 2¾ in., as ⅛ in. of the material has been removed from each face for planing purposes.

Prepared Boards.—The same applies to prepared boards. For example, a 6 in. by 1 in. floorboard planed on one face and two edges will only "hold up" to 5¾ in. wide and ⅞ in. in thickness.

The effective width of tongued and grooved boards is usually ½ in. narrower than the "nominal" width.

Planks, deals and battens, etc., when sold in large quantities are generally at so much per "Petersburg" standard, representing 165 cubic ft. From this it is simple to calculate the number of running feet of material of any sectional dimension contained in a standard of timber by applying the following simple formula:

$$FR = \frac{144}{N} \times 165$$

where FR = the number of feet run, and N = the sectional area of the material in square inches.

For example, how many feet run is contained in a standard of 4 in. by 2 in. timber?

Applying the above equation we have:

$$FR = \frac{144 \times 165}{8} = 2970 \text{ ft. run per standard.}$$

These quantities, however, are seldom if ever required by the handyman, and the above example is only mentioned as a point of interest.

The amateur generally buys his scantling and quartering at so much per 100 ft. run, and floorboards and matching at so much per 100 ft. super, which means 100 square ft., usually termed a "square."

Hardwood, such as oak, etc., is generally sold at so much per square ft. up to 1 in. in thickness, but timber above this thickness is frequently quoted at so much per in. thickness per square ft. For example, a piece of hardwood 1½ in. thick at 4/- per in. would cost 6/-.

It may not be out of place here to mention that a price should always be asked before giving a definite order for timber as prices vary a great deal. For instance, it is often possible to get quite good quality, say, 2 in. by 3 in. stuff at some yards for practically the same price as that asked for 2 in. by 2 in. at others.

This is a point worth considering, especially when the material is to be used for constructing a workshop or a shed, because 2 in. by 3 in. studding makes a stronger job than 2 in. by 2 in., and in this case costs little if any more.

Before paying a visit to a timber-yard to place an order for wood it is a good plan to work out the quantities required, and make a note of them on paper, giving the size of each item. The reason for this is that the timber merchant, although generally willing to give every assistance, cannot be expected to sort out exactly what is asked for—if you expect it you may be disappointed.

If you require a number of varying short lengths, calculate them so that their added lengths are equivalent to the number of standard 12, 13 or 15 ft. lengths, as the case may be. This method of ordering is not only economical, but saves a great deal of time and puzzling when you come to cut the timber to the required sizes.

Do not be surprised if, after having ordered, say, 12 ft. lengths, you receive pieces 13 ft. long, for it often happens that material of a specified length is out of stock. In such cases the merchant usually sends the nearest longer size to that ordered, which is very often a blessing in disguise.

Tongued and Grooved Matching is a particularly useful prepared wood of great service to the amateur for covering workshops, sheds, etc. It can be obtained in listed widths of 4, 4½, 5, 5½, and 6 in., and in thicknesses of ½, ⅝, ¾, and 1 in.

There are two kinds of this material. One has a moulded bead on one edge and is known as beaded matching (illustrated at A in Fig. 1), and the other has both edges bevelled to form a V between the joint (as shown at B). The latter is recommended because it generally forms a stronger joint, and has perhaps a more pleasing appearance when erected.

When ordering matching it is necessary to specify which of the two kinds is required.

Do not overlook the fact that the thickness of matched boards is ⅛ in. less than the listed thicknesses, that is, ⅝ in. matching is only ½ in. thick. Also, that a matched board when joined to its neighbour loses ½ in. from its standard width. This is important, because if you estimate the number of boards required to cover a given length on the basis of listed widths—say, for instance, the back of a shed—you will find that you have an insufficient number of boards to complete the work.

For example, suppose you wish to cover a length of 12 ft. This would require 24 6-in. nominal sized boards; but as the true width of such boards is only 5½ in., over 26 such boards would be necessary.

It follows from this that the narrower the board used the greater the deficiency will be. Thus, if 4 in. boards are substituted in the example quoted above, 36 boards of nominal width would be necessary, but as each board loses ½ in. in width the 36 boards would cover only about 10 ft. 6 in.

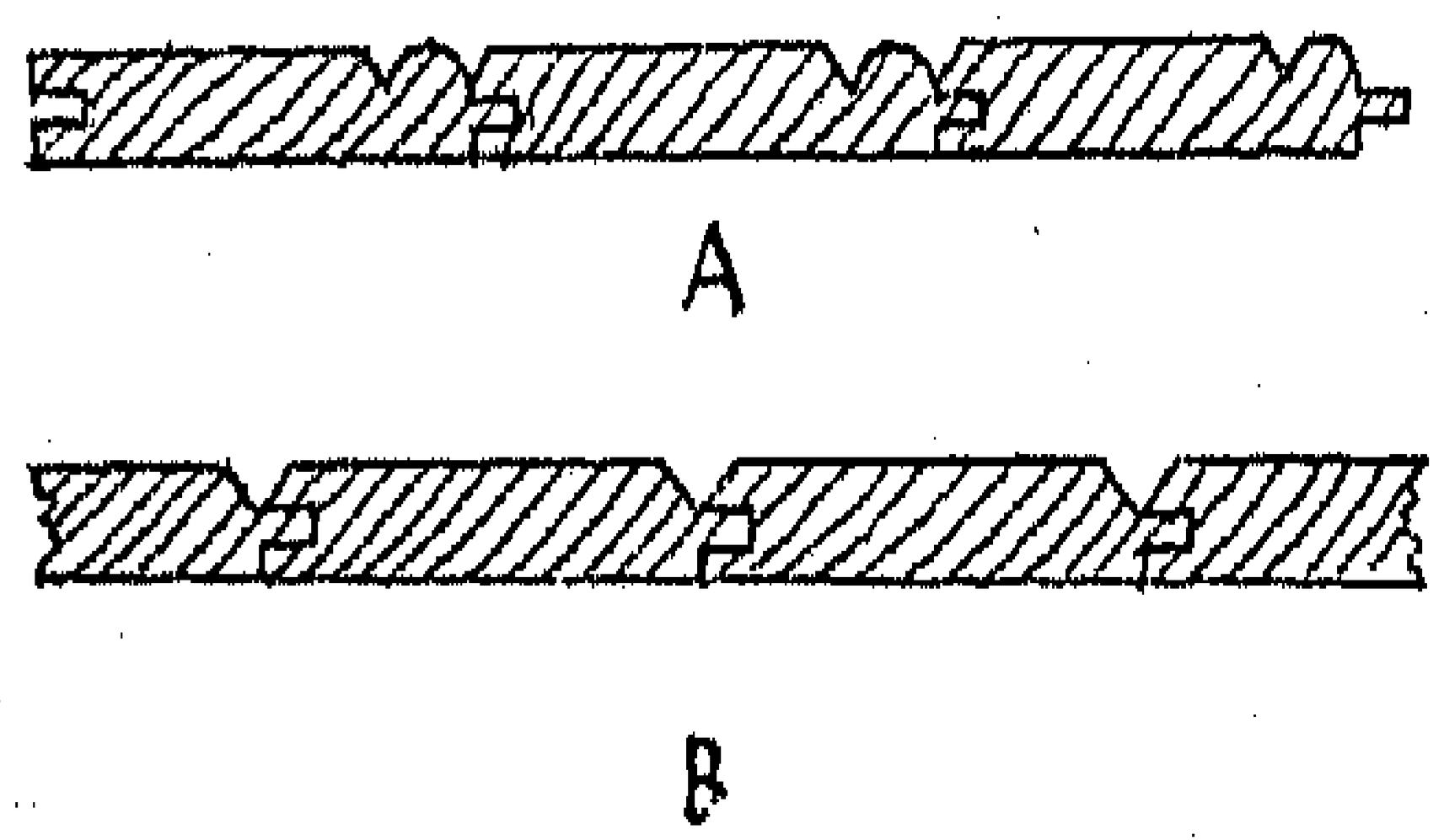


Fig. 1

Like all softwood, tongued and grooved boards shrink and swell an appreciable amount according to the state of the weather. If erected whilst in a wet condition the work will open out and possibly expose the tongues when it has had time to dry. This should be borne in mind when trying to make up your mind whether to use wide or narrow matching. The wide stuff covers the ground more quickly; and, as bought, loses less in width than the narrow material, as already mentioned; but it shrinks more as there is more substance to shrink. On the other hand, narrow boards do not shrink so much, but you lose a great deal more in covering capabilities.

It is false economy to use very thin matching as there is more risk of finding both tongue and groove broken, especially in the ½ in. stuff. This comes to you only ⅜ in. thick, and when you consider that this is divided into three—with the face edge a little thicker than the back portion—you will quite readily understand that some of the back part of the grooved edge, and also some of the fragile tongue often gets broken off in handling.

When nailing matchboards in a vertical position, always start with a grooved edge flush or just overlapping the vertical supporting member, so that the groove of the next board to be fixed fits into a tongue. This method not only ensures easier working, but presents a stronger edge should it be necessary to knock the succeeding board in place.

Do not strike the unprotected tongue of a board when using a hammer for forcing a board in position, as the tongue will either break or spread out and thus render the next board difficult to fit. This can be prevented by placing the groove of an odd piece of matching over the tongue of the board to be fixed, and striking this.

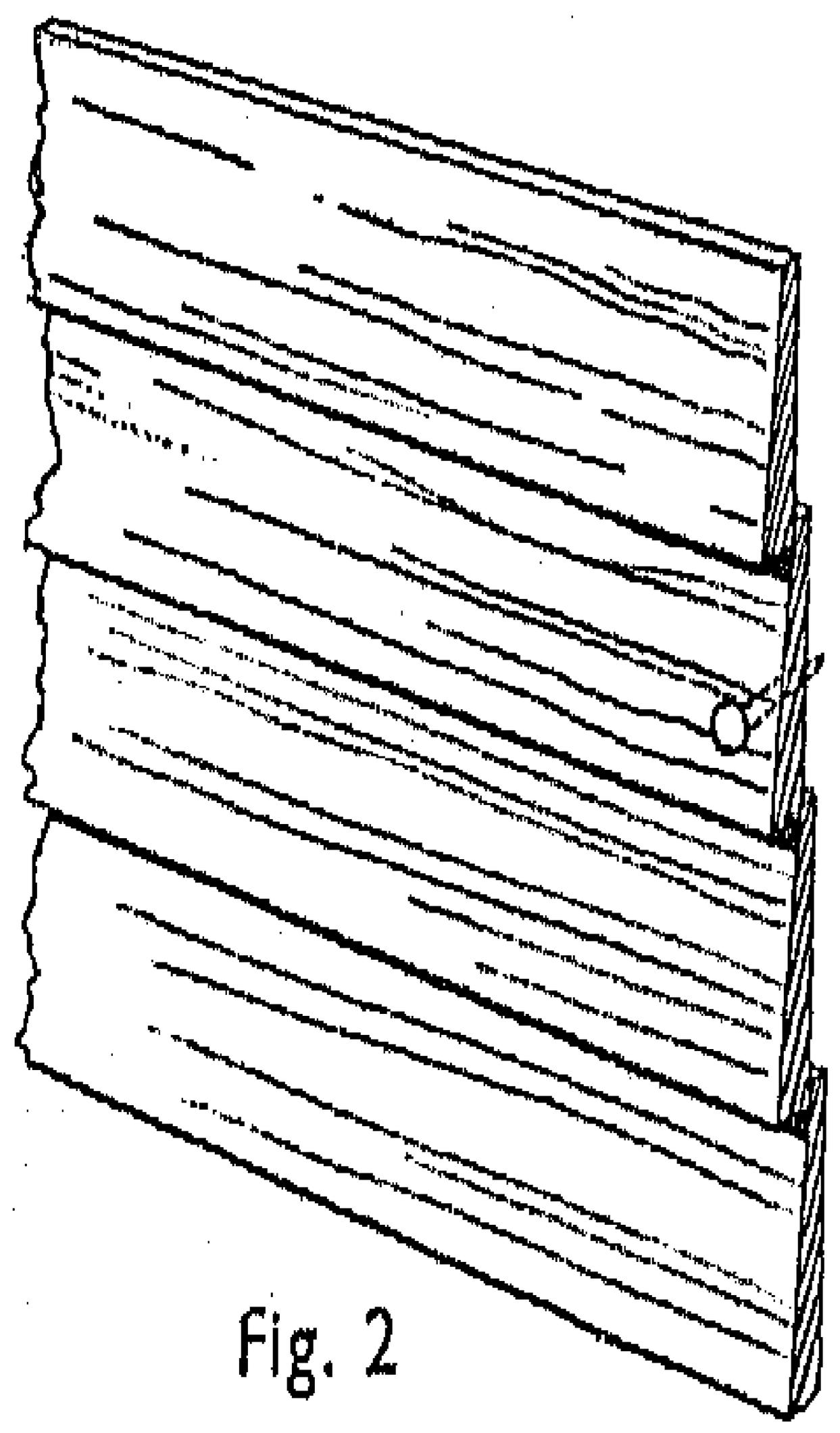


Fig. 2

When fixing matching in a horizontal position out of doors, always keep the tongued edge uppermost, as it allows rain, etc. to run off. If the board is fixed with its groove to the top, water may lodge in the groove and remain there for some appreciable time, obviously damaging the wood.

As it is usual either to paint or creosote the exterior of matched boards used for covering sheds and other structures exposed to the weather, to preserve the wood, it is an advantage to apply a little of the finishing material to the joints as they are being fitted. This protects the wood at its weakest parts and helps to keep out the weather.

Weather-boards are used extensively for covering sheds, poultry-houses and similar structures.

In the common weather-board, sometimes called feather-edge board, the section is cut obliquely and produces a wide and a narrow edge—as shown in Fig. 2. They may be obtained either roughly sawn or sawn and planed, and with or without a rebate; the rebated board (Fig. 3) being easier to fix than the plain-edged one.

Weather-boards are, of course, used horizontally and when being fixed to the framework should be started from the bottom with their thick edge downwards.

When fixing plain weather-boards care must be taken to give sufficient overlap and to keep them level. A spirit-level comes in handy for levelling, but if such a tool is not available, the two end uprights of the framework can be marked at equal distances to suit the width of the boards.

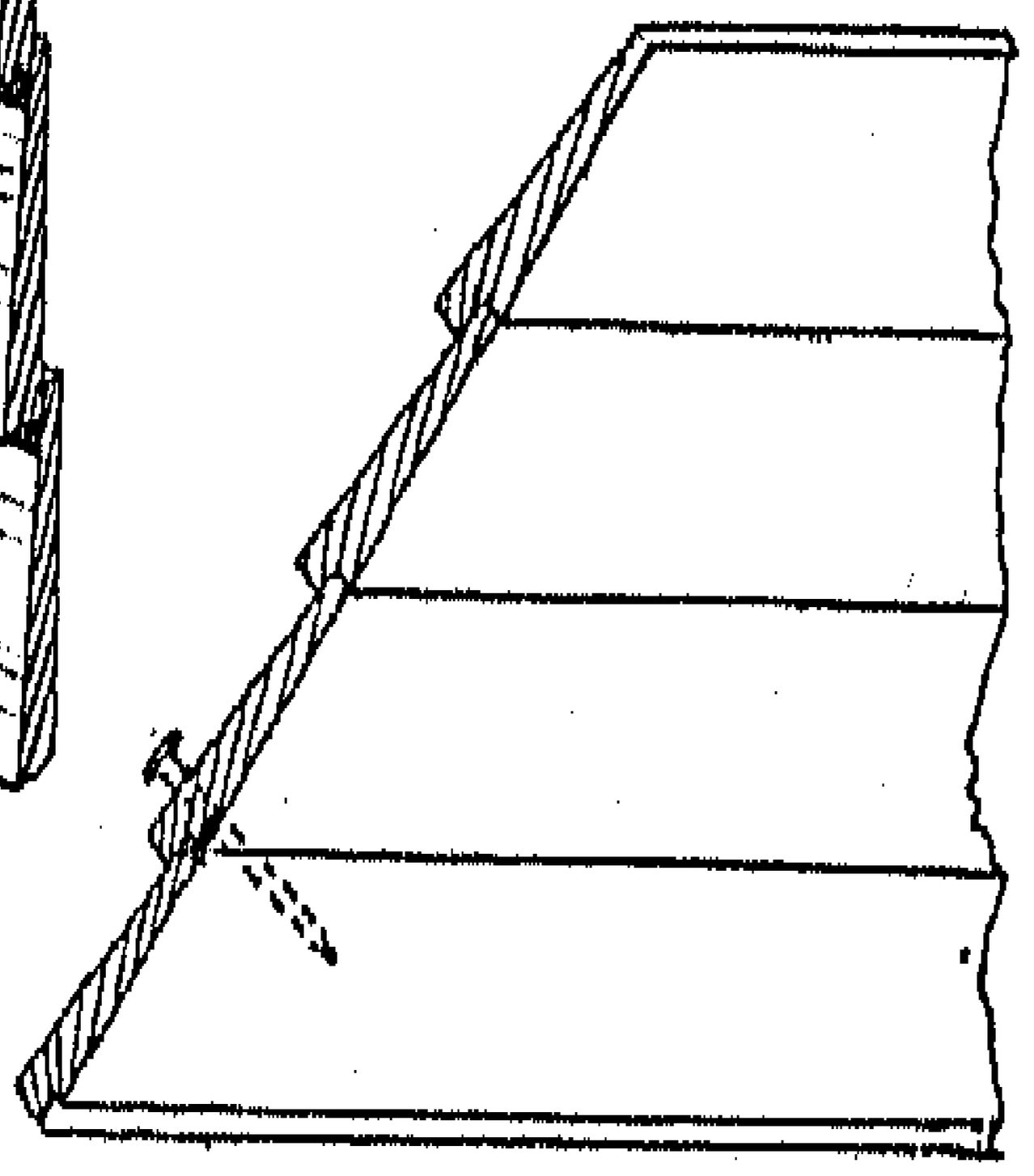


Fig. 3

The nails should be driven in so that they pass only through one board (as shown in the illustrations, Figs. 2 and 3).

The same remarks apply to fixing rebated boards, except that there is no need to mark the positions as the rebates keep them parallel. If a spirit-level is available it is as well to check

parallelism after fixing, say, every fifth board.

The nails should be driven in at not less than ¾ in. above the thick edges to prevent them going through and perhaps splitting the thin edge of the previous board. This distance also allows a little latitude for expansion and contraction.

French nails about 2 in. long are useful for fixing weather-boards, as they have a fairly large head, and if driven on the slant ensure a strong fastening.

The effective width of a 6-in. rebated weather-board is only 5⅜ in., as the rebate is generally ⅝ in. deep.

Fig. 4 shows a modern type of weather-board introduced from Canada a few years ago. It makes a neat and effective covering and offers a level outer surface, and like the ordinary rebated weather-board, gives a level inside face, which a plain feather-edged board does not.

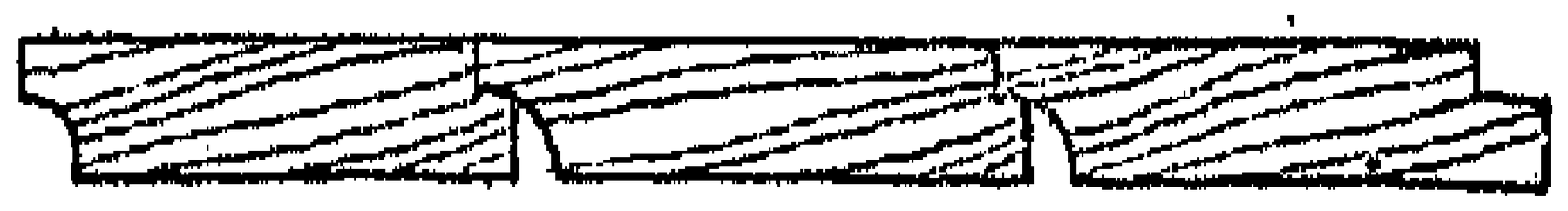


Fig. 4

It is hardly necessary to state that all timber should be stored in a perfectly dry place having a free circulation of air. Any timber required for outside work which cannot be conveniently stored under a roof should be kept off the ground and covered up with sacks, linoleum, or galvanised iron to keep out the weather as much as possible.

TOOLS AND THEIR USES

THE question of tools is as important to the woodworker as the materials they are to be used upon, for without a suitable equipment it is impossible to turn out neat and accurate work. It is said that a good workman can do good work with any tool, whatever its condition may be, but that is a myth and you can be assured it will be done more satisfactorily and expeditiously with a good tool kept in good condition.

A large number of tools is unnecessary at the outset, as the simpler kind of woodwork can be done by the skilful use of a few, but those few should be of the finest quality your pocket will allow.

The best and most economical way of getting a kit of tools together is to go to a reliable firm of tool dealers and purchase guaranteed tools. Buy the articles singly and gradually add to the equipment as necessity arises.

The purchase of good tools should be regarded as an investment, as they will soon pay for themselves and last a lifetime if properly used and cared for.

Take particular care that all cutting tools, such as chisels, planes, etc., are not allowed to lie about in a slipshod fashion on the bench, or put into a drawer with other tools, as their cutting edges are liable to be chipped. When a plane is finished with for the time being, place it on its side and not on its working face. Use only the tool intended for its particular purpose and do not be tempted to turn a screw with a chisel if a screwdriver is not immediately at hand. Another important point worth mentioning is always to keep your tools under lock and key and if tempted to lend a tool—which is bad practice—make sure that the borrower returns it.

The wooden parts of planes and chisels are sometimes french-polished to add to their appearance. It certainly does not add to their durability, but what would do so would be to soak the chisel handles in linseed oil for a day or two, rubbing them daily with a cloth. The same suggestion applies to a plane. Remove the plane iron, stop up the narrow opening at the base with paper or rag, fill the aperture with linseed oil, and put it by for a time to allow the oil thoroughly to soak in.

This treatment preserves and solidifies the wood.

The metal parts of all tools should be kept free from rust, as a sharp edge cannot be made on cutting tools after they have been allowed to get in a rusty condition. The simplest plan to prevent rust is to keep the tools in a dry place and give them an occasional rub with an oily rag.

For a start, the amateur woodworker is advised to obtain a claw-hammer, hand-saw, tenon-saw, brace and bits, screw-driver, bradawl, try-square, marking-gauge, rule, and a trying-plane. Although the general practice is to have a jack-plane at the outset, a trying-plane is perhaps the more useful tool, as the majority of the material employed, especially at the beginning, should be bought ready prepared.

The Hammer, three types of which are represented in Fig. 1, is perhaps the most frequently used tool. It is made in various forms, sizes and weights. A good hammer has a cast-steel head and when made by a reliable firm is a well-formed, nicely-balanced tool, with its striking-face made slightly convex to prevent damage to the timber when the hammer strikes the surface.

The Claw-hammer (shown at A in Fig. 1) is recommended as the amateur's first choice because, in addition to being a striking-tool, it is useful for extracting nails when pincers are not available. If the nail to be withdrawn is a long one, it is advisable to place a piece of wood under the head to obtain a more direct pull, as a nail usually comes out straight. This method prevents the nails from being pulled, as it were, round a corner.

The Warrington Hammer (represented at B) is a favourite tool among woodworkers, and may be termed a general purpose hammer. It has a wedge-shaped edge opposite the striking face, which is useful for hammering in confined spaces or starting small brads and nails.

The Tack-hammer (C) is useful for light work, such as cabinet-making, and driving in small brads, panel pins and the like.

The Mallet (shown in Fig. 2) consists of a wooden head made of hardwood—usually beech, but better in apple wood—fitted to an ash shaft or handle. It is used principally for striking the wooden handles of chisels, gouges, etc., where the use of a hammer would damage the tool. The head is generally rectangular in form. As a rule the shaft is fitted to the head in a similar way to that used in the pickaxe; that is, the handle is made larger at the head end, which enables the shaft to pass through the hole in the head. This causes it to bind and grip the head firmly.

Mallets may be obtained in several sizes, but a medium-sized tool usually satisfies the needs of the amateur craftsman.

The practical man requires at least two saws, one for cutting large work and the other for smaller work at the bench.

The Panel-saw (an illustration of which appears at Fig. 3) is a general purpose saw and therefore a useful tool from the amateur point of view. It is usually about 22 in. in length and has from 6 to 8 teeth to the inch.

The Rip-saw is about 28 in. in length and has coarser teeth than the panel-saw,

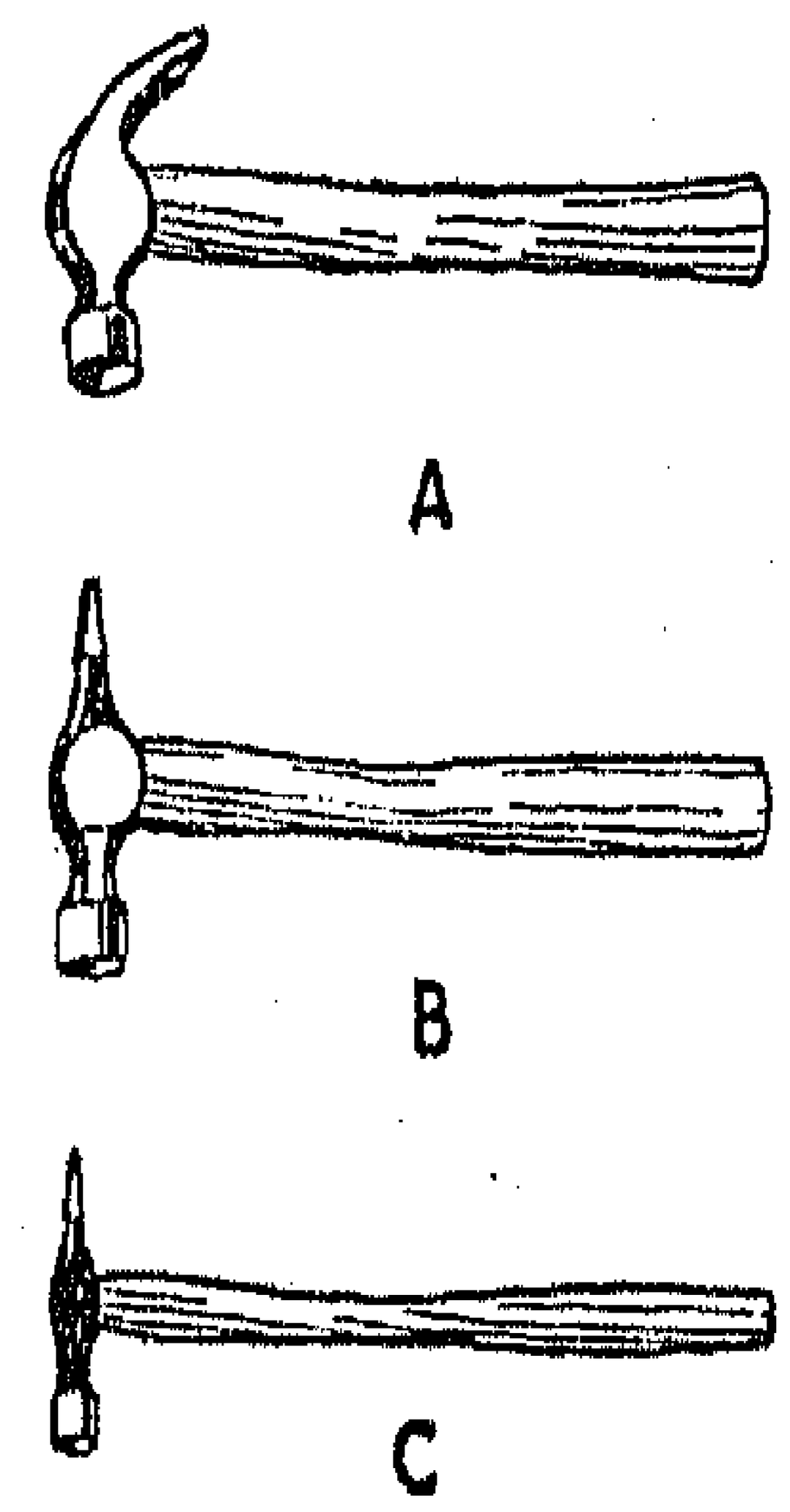
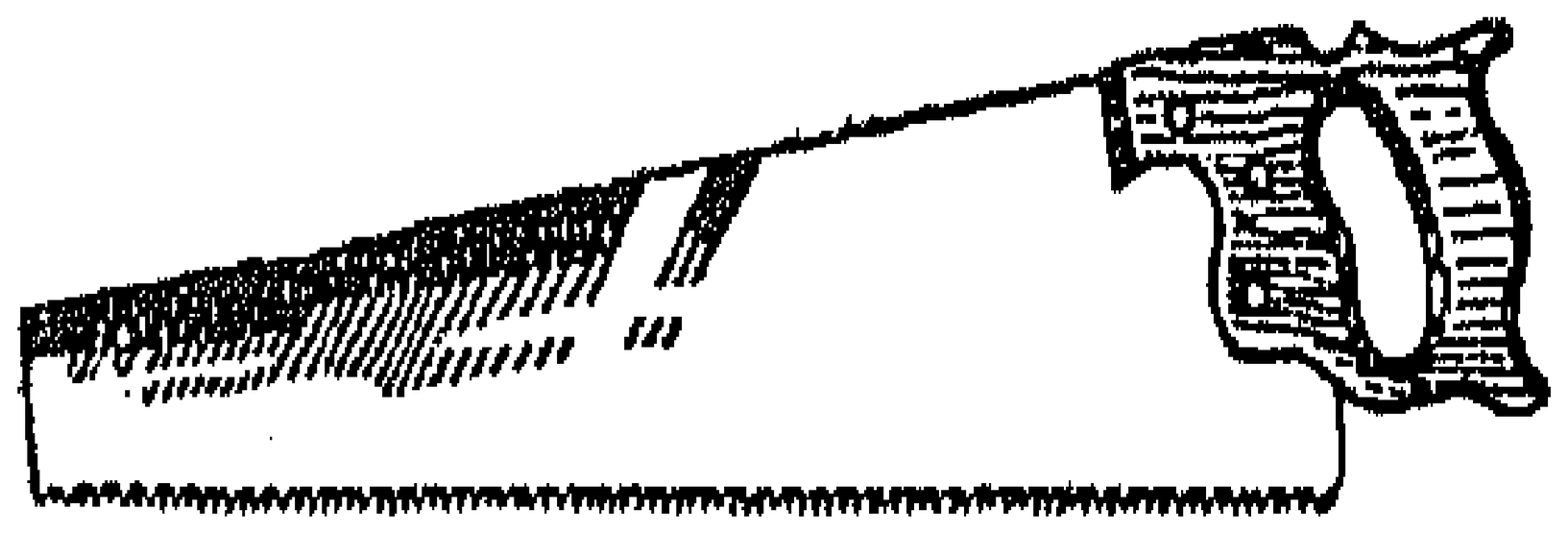


FIG 1



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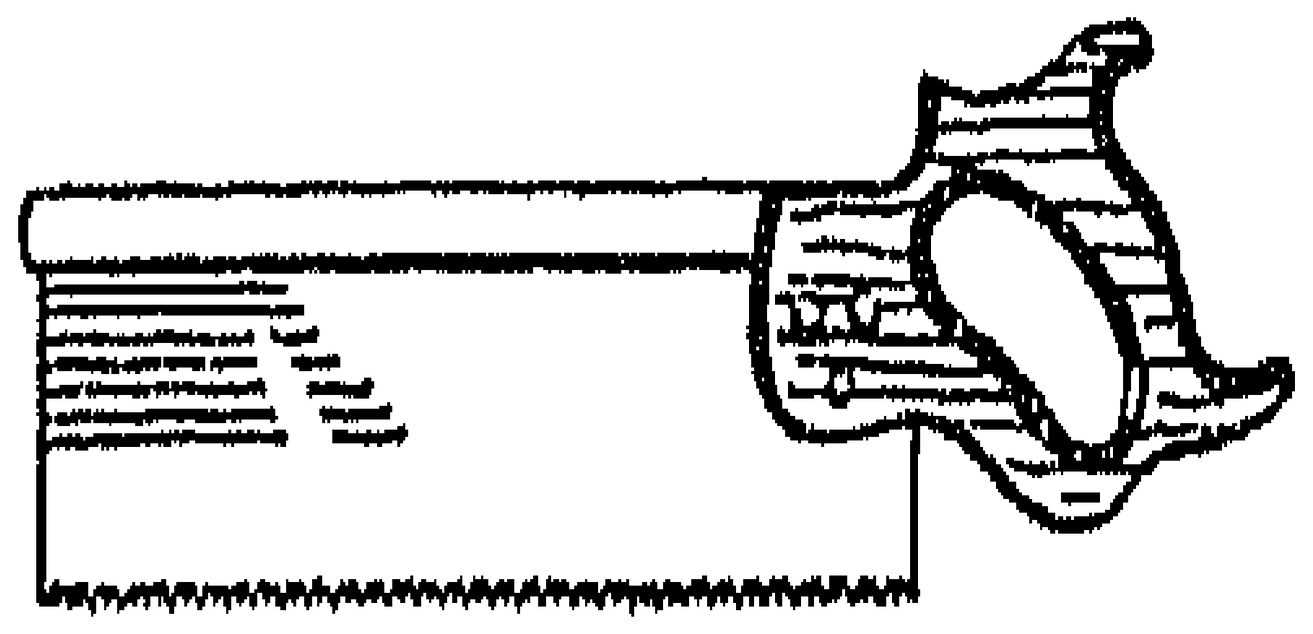

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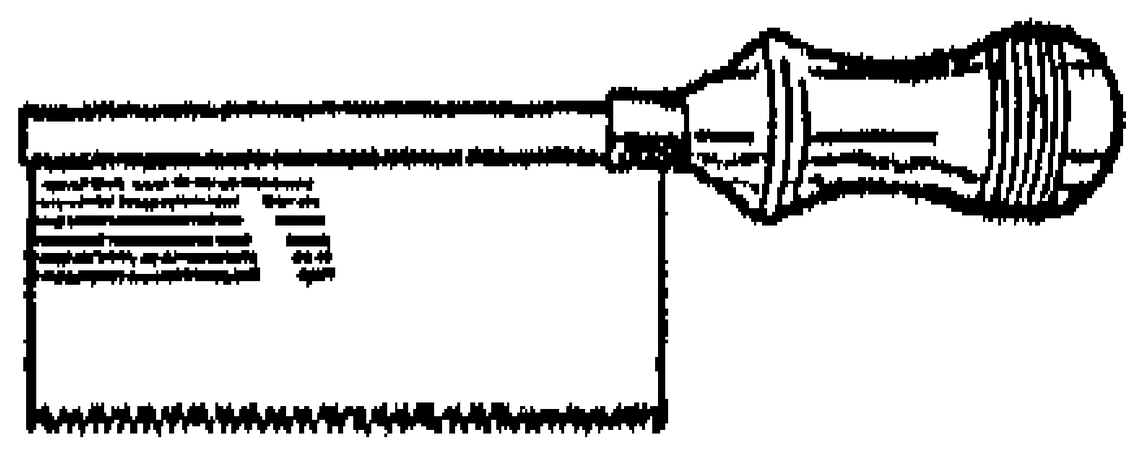

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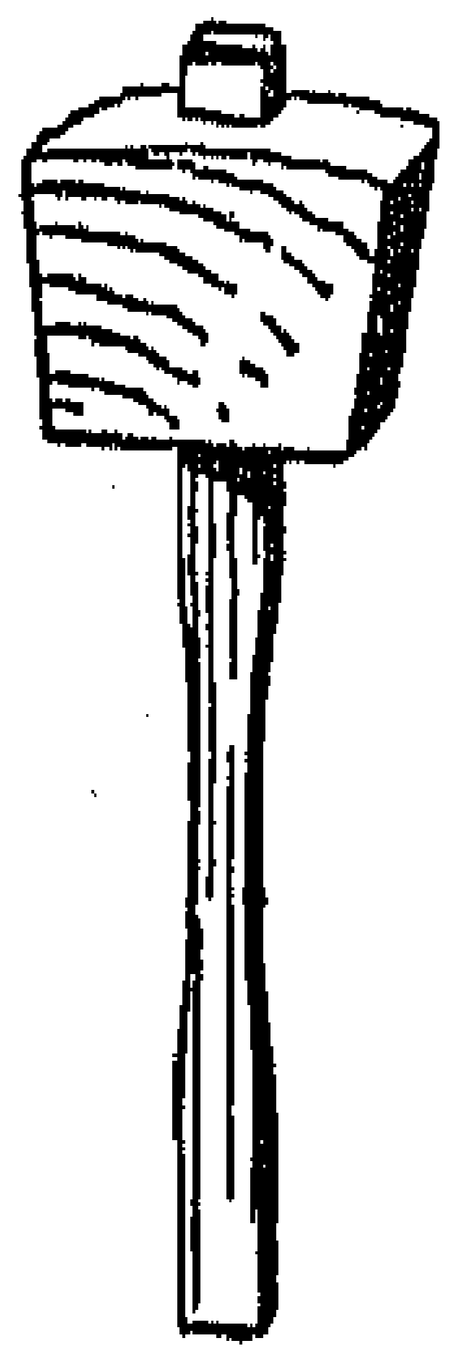
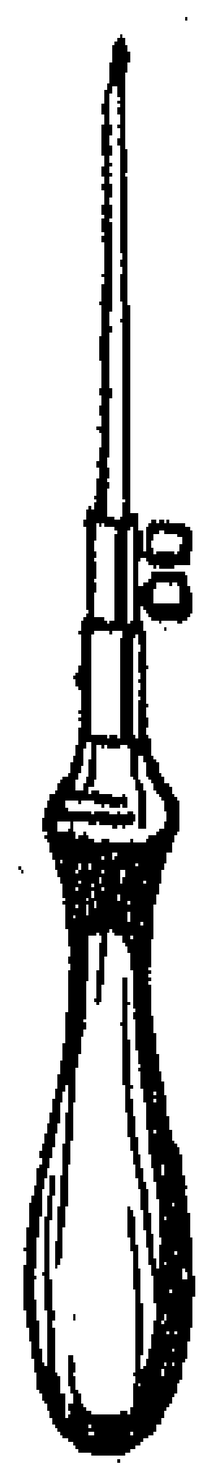


FIG 2



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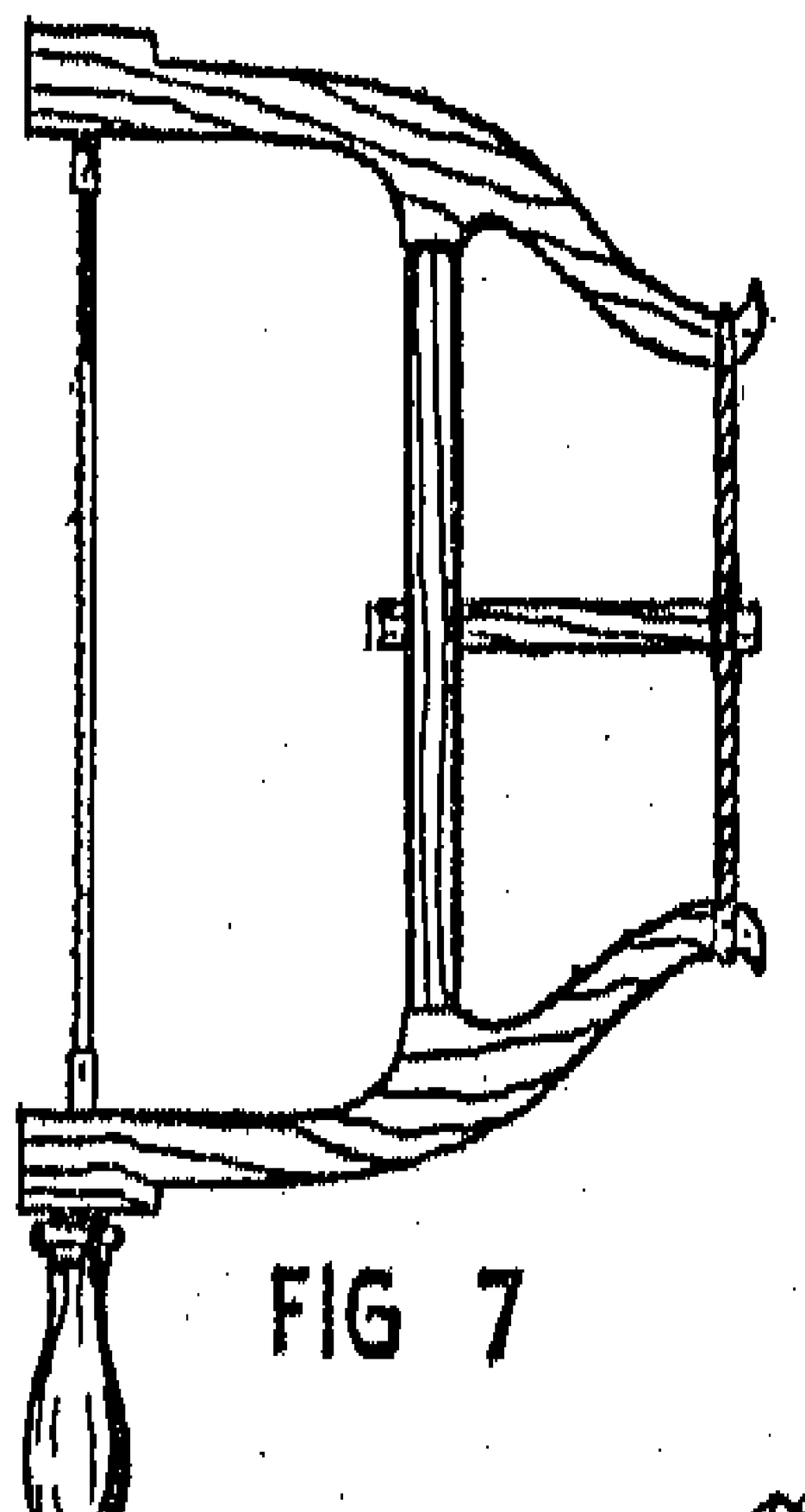


FIG 7

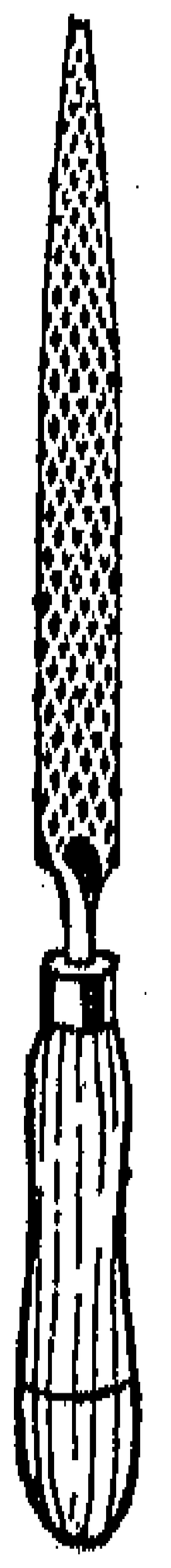


FIG 8

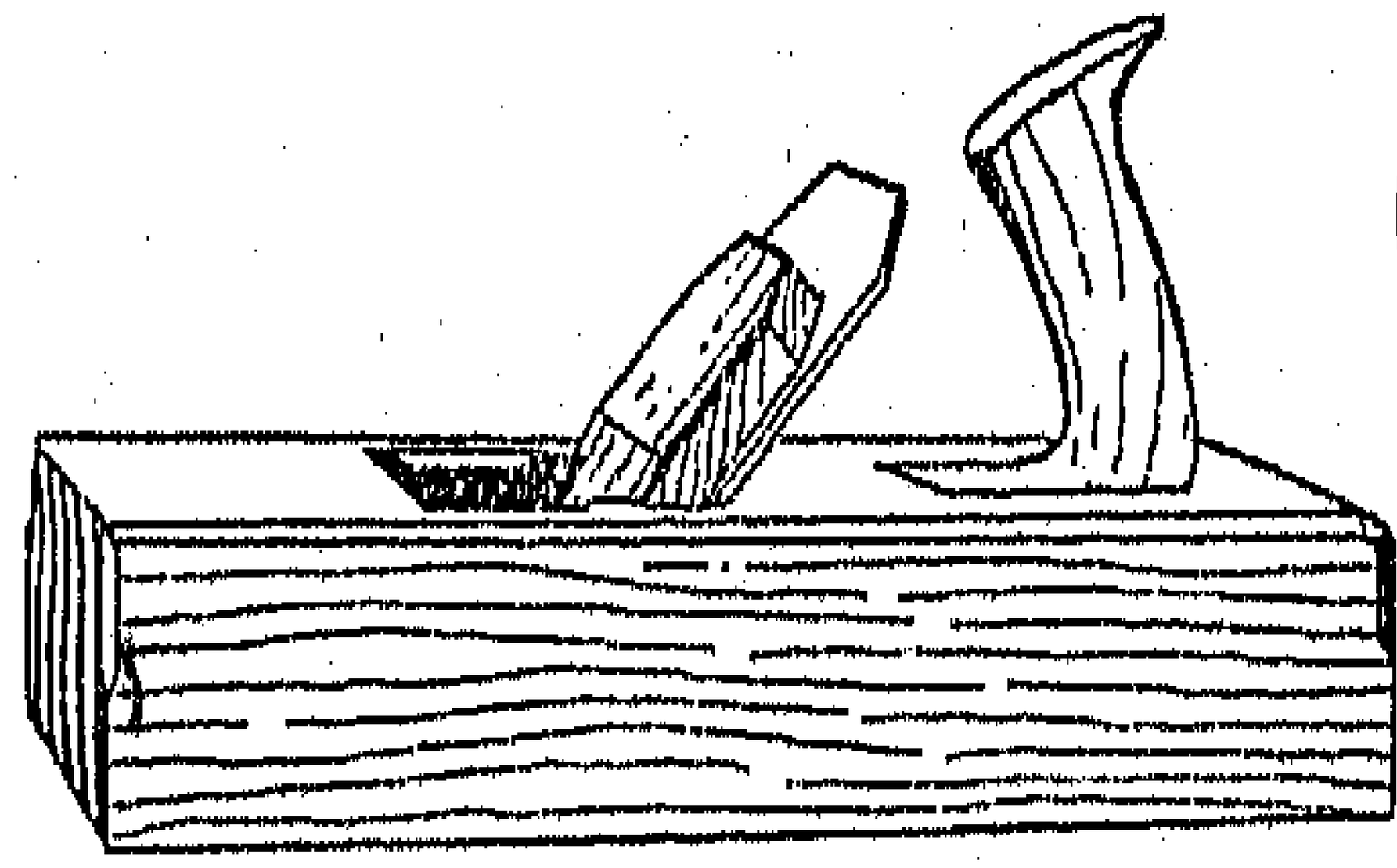


FIG 9

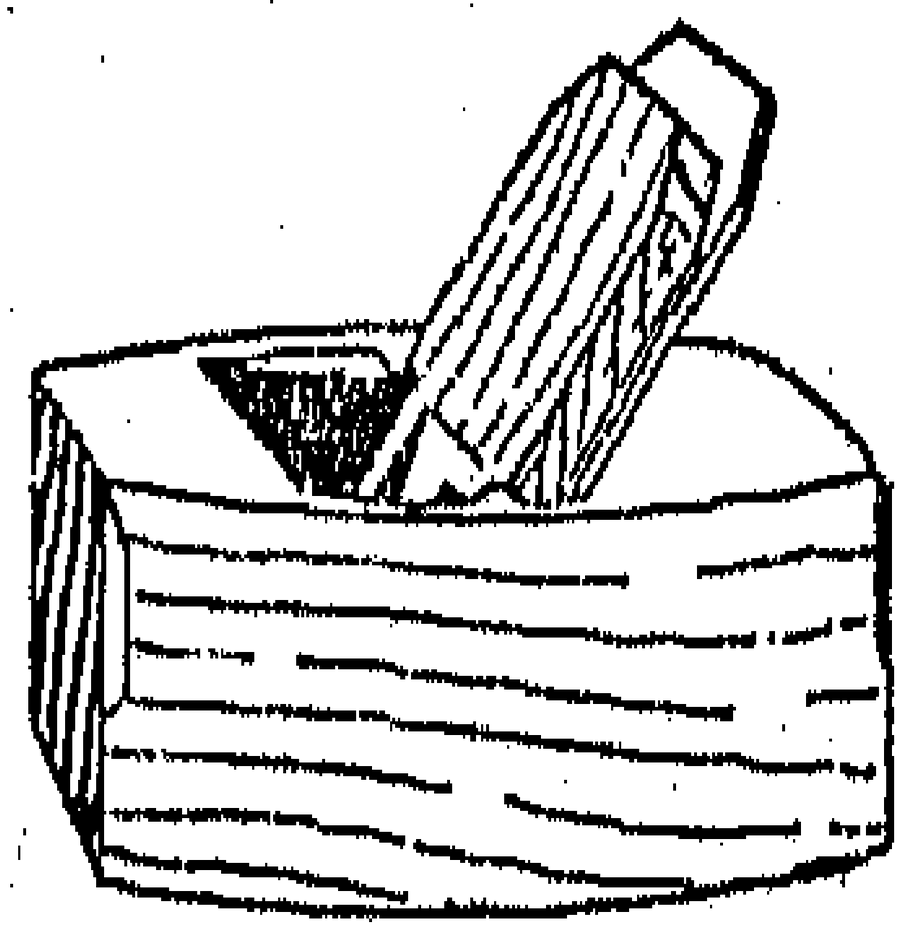


FIG 10

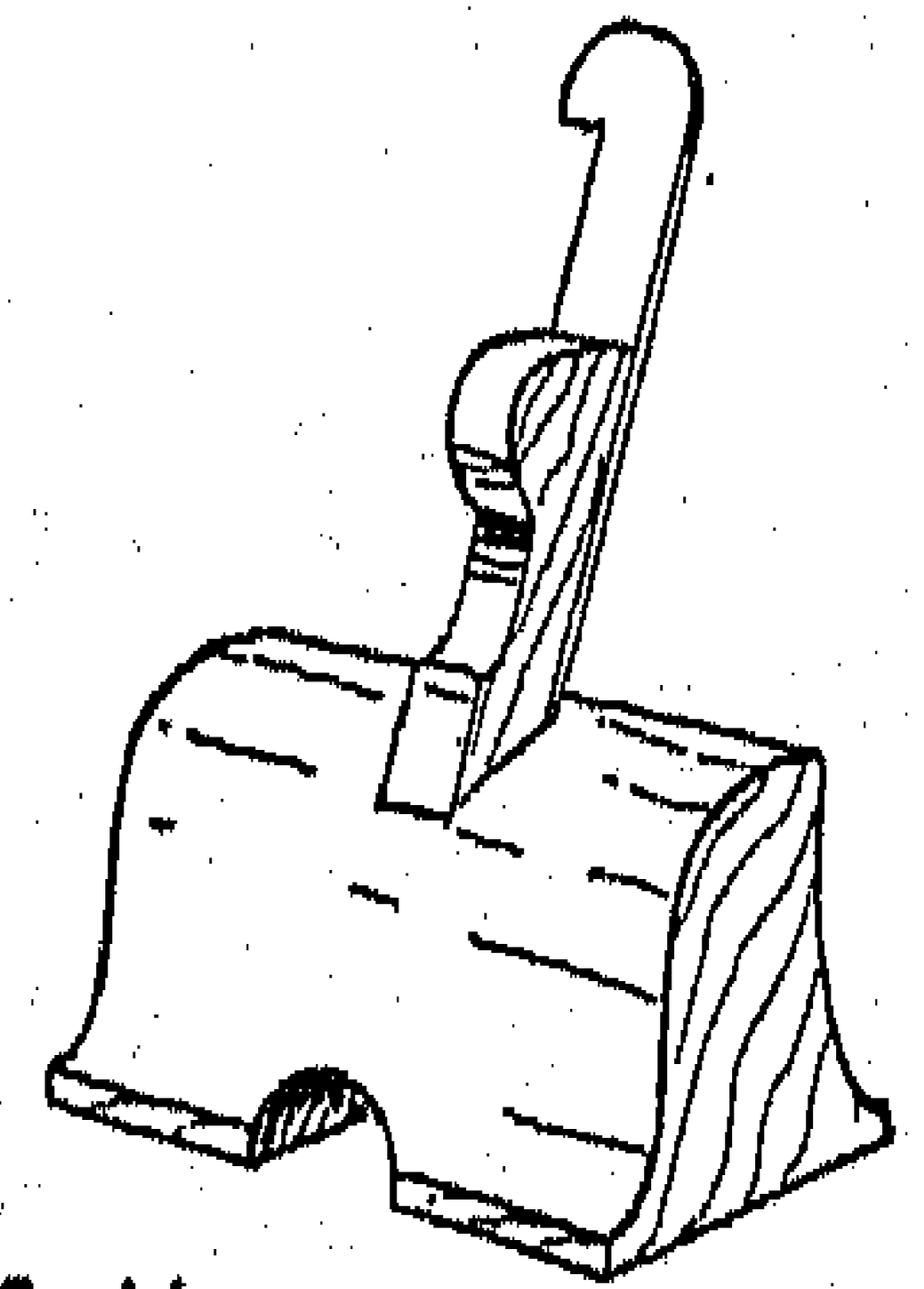


FIG 11

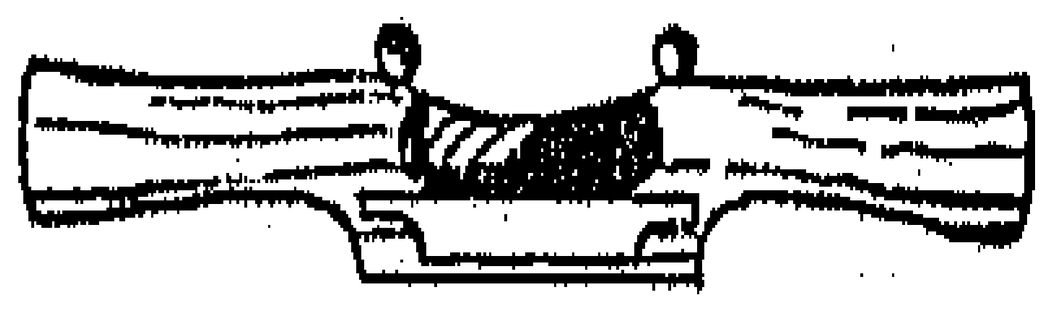


FIG 12

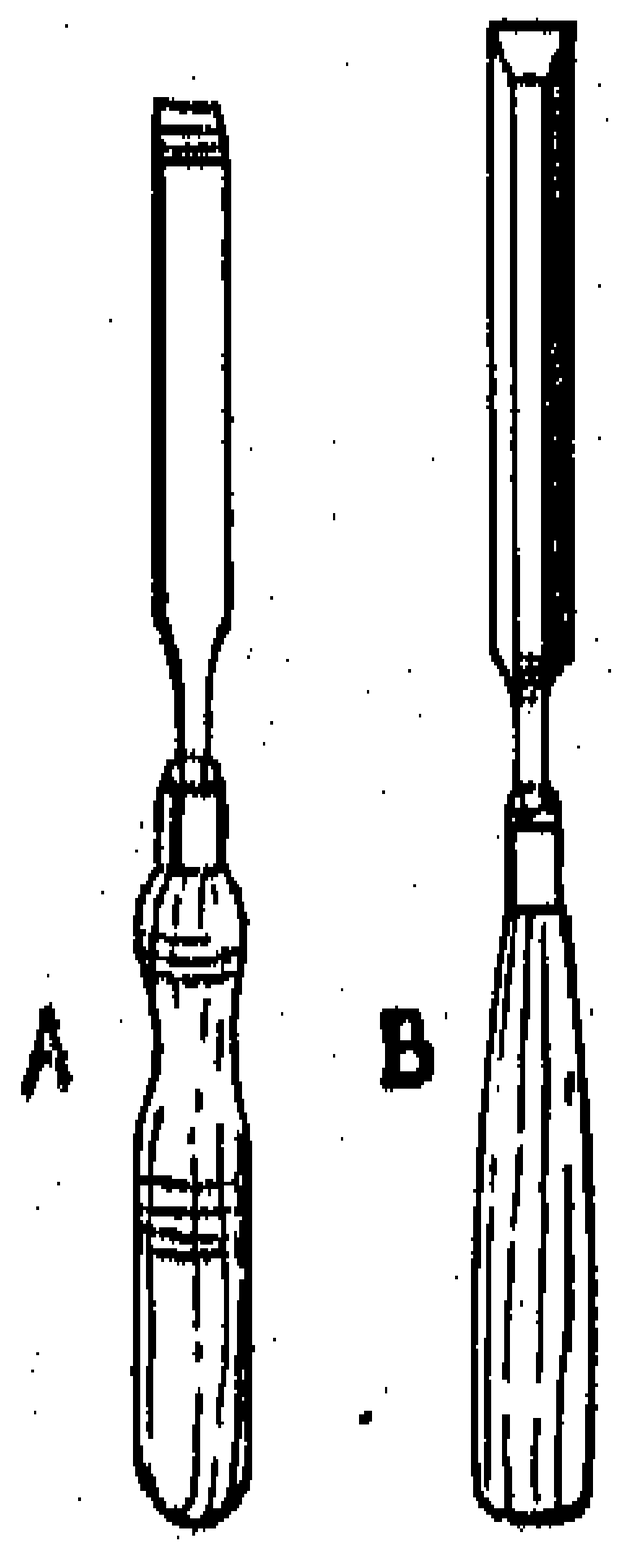


FIG 13

usually 3 or 4 to the inch. It is used for cutting in the direction of the grain of the wood.

Cross-cutting Saw.—For cutting across the grain a cross-cutting saw is used. One having 6 teeth to the inch is a useful type, as it can be used for sawing both hard and soft wood.

When purchasing any of the saws mentioned above, you are strongly recommended to get one of a reliable make, otherwise you are likely constantly to rue your purchase. A good saw should be made with an even temper throughout, springy and elastic. If badly tempered or soft it will soon get dull and consequently need frequent sharpening. An inferior saw usually buckles easily, and gets out of truth, which defies reasonably correct sawing. In a good saw the point end of the blade can be bent to touch the handle, and when released should fly back to its original position without showing any sign of distortion.

Tenon-saw.—Fig. 4 shows a tenon- or back-saw as it is sometimes called. It is much smaller than the hand-saw and is essentially a bench tool although sometimes used off the bench. As its name implies, it is used principally for cutting tenons. Tenon-saws vary from about 12 in. to 16 in. in length and have about 10 teeth to the inch. As the blade is very thin a thickened piece of steel or brass is attached to the back to keep it rigid.

The Dovetail-saw is a small edition of the tenon-saw and has about 12 teeth to the inch. It is used for fine work such as dovetailing, etc.

Brass-back Saw.—Fig. 5 shows a small brass-back saw, which is extremely handy and should find a home in every woodworker's kit.

Pad-saw.—Fig. 6 represents a pad-saw or, as it is sometimes called, a key-hole saw. It is fitted with a narrow, tapering blade which makes it particularly useful for cutting curves, both external and internal, keyholes, etc. The blade is adjustable and slides in the handle. It is kept in position by two binding screws. This feature enables the blade to be shortened or lengthened as required. As the blade is rather soft it is liable to buckle, so care must be taken when being used to avoid twisting. In selecting a pad-saw get one with an 8-in. blade.

The Compass- or **Lock-saw** is very similar to a pad-saw, but as the handle is a fixture the length of the blade cannot be adjusted.

The Bow-saw (Fig. 7) is a sort of frame-saw with the blade held in tension by means of a twisted cord similar to that in the tourniquet. It has a very narrow blade which allows small curves to be negotiated. As a rule it is used when the curve starts from the edge of the wood. Its place, from the handy-man's point of view, is easily taken by the pad-saw and the fretsaw.

Rasp.—As its name implies, a rasp is used for rasping or filing, and is handy for finishing off inside curved work after it has been cut out with a pad-saw. The amateur would be well advised to include one in his outfit. The form recommended is the shoemaker's rasp, of the half-round, medium-smooth type, as shown in Fig. 8.

A plane—one of the most important tools in woodworking—as its name signifies, is used for preparing plane surfaces. Planes can be obtained in either wood or metal, in various shapes and sizes, each of which is designed for its particular purpose.

Try-plane.—Fig. 9 shows a try-plane, which should be acquired by the amateur in preference to a jack-plane, as most of the timber used will be bought ready prepared. It consists of a stock or body—usually made of beech as this material is more or less free from twisting and warping—provided with a handle for propelling it along the work, a plane-iron, and a hardwood wedge to keep the iron in position. The bottom or sole of the tool is perfectly flat, and has a slot across it through which the cutting-edge of the iron projects. The thickness of the shaving it is intended to cut is regulated by the amount of cutting-edge exposed to the work, and is adjusted by means of the wedge. Plane-irons are made of steel and are fitted with a back-iron screwed to the blade. This extra iron gives additional support to the cutter and breaks the shavings when being cut. To loosen the iron the body of the plane is held in the left hand and struck smartly with a mallet on the top at the front end of the tool.

Smoothing-plane.—Fig. 10 shows a smoothing-plane, which is a much smaller tool than the try-plane. It is used for finishing a surface after it has been trued up with a try-plane. As the tool is held differently to the try-plane a handle is unnecessary. The iron is loosened by holding the body with the left hand and supporting the wedge and iron with the thumb and then smartly tapping the back end of the tool.

Router-plane.—Fig. 11 shows a type of plane called a router, or "old woman's tooth." It is not very often seen in these days, yet it is, nevertheless, extremely useful for finishing housing joints used in the uprights for shelves and partitions in drawers, etc. It consists of a narrow plough-iron fixed by a wedge in a suitably shaped piece of hardwood, and is held with both hands. When using the tool it is advisable to choose an iron of less width than the groove to be cleared. The groove is made in the ordinary way with the saw and chisel and then followed by the router, which is first worked from one edge of the wood towards the centre and then from the opposite edge towards the centre.

Other planes include the rebate, the plough, and various beading and moulding planes, and others for special purposes.

Many of these planes are duplicated in metal. They are heavier, but they have the advantage that the sole does not wear away as in the case of a wooden plane. The plane-iron is adjustable to various cutting angles within its range, by means of a screw adjuster. This feature is very useful as it enables the plane-iron to be altered to suit soft or hard wood.

The Spokeshave (Fig. 12) is what may be termed a small double-handled plane and is used for finishing curved surfaces. There are several types, all of which work on the draw-knife principle, that is, a cut may be taken by drawing the tool over the work, or it may be pushed to obtain the cut. The blade can be set for fine or coarse cuts. The spokeshave is not a particularly easy tool to use and only light cuts can be taken.

In Fig. 13 (at A and B) are shown two types of wood chisels, known as the firmer and paring respectively.

The Firmer-chisel is the tool most commonly used and may be termed a general purpose chisel. They are to be obtained in sizes ranging from $\frac{1}{16}$ in. to about 2 in. The hardened steel blade containing the cutting-edge is generally fitted into an ash or boxwood handle having a brass ferrule to prevent splitting. For ordinary everyday work a set of chisels, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and 1 in. wide, fitted with octagonal handles, should be included in the tool equipment.

A Mortice-chisel is used for cutting mortices, and has a thick blade, so formed to help to keep the mortice true. Like all chisels it has a bevel on its cutting face. If the flat side of the tool is not held firmly against the edge of the cut it usually cuts inwards, and if held with the bevel to the cut it will cut outwards. A mortice-chisel is not much used in these days by the amateur, as the brace and twist-bit is generally used for first removing the waste, followed by a firmer-chisel for finishing.

The Paring-chisel is similar to a firmer, except that the blade is not so thick and the front and side edges are bevelled. As its name suggests, it is used for paring wood.

To get the best results when using chisels they must be sharp, for good work cannot be done with blunt tools, as they tend to bruise the wood more than cut it. A chisel should never be struck by a hammer: the mallet is the correct tool to use for this. If a mallet is not available, use a piece of wood, say, 9 or 10 in. long and 2 in. square, thinned down at one end to form a handle.

Gouges are really chisels with a curved cutting-edge and are used for circular work. They are to be obtained with either externally or internally ground cutting-edges. For general work the internally-ground tool will be found useful. An internal- and an external-ground gouge are illustrated in Fig. 14 at A and B respectively.

Brace bits, gimlets and bradawls come under the heading of boring tools.

The Bradawl (illustrated in Fig. 15) is made in many sizes. It is a very simple tool and consists of a blade with a wedge-shaped cutting-edge, fixed into a handle. It is used mostly for making small holes for the insertion of nails or brads; hence its name. When using the bradawl the cutting-edge must be across the fibres of the wood, otherwise the wood will split. Force must be used when employing the tool, either by hand or tapping it with a hammer.

The Gimlet (Fig. 16) does not require force or pressure as it has a screwed point which draws the tool into the wood when turned by the handle. It is used principally for making holes for the insertion of screws, and can be obtained in many sizes. It is rather a dangerous tool, especially when used near the end of a piece of wood, as it is likely to split it. For such holes it is advisable to use a metal hand-drill fitted with a twist-drill (as illustrated by Fig. 17).

Bits.—Fig. 18 shows a number of boring bits in various forms extensively used by woodworkers. The bits are held in a brace, an illustration of which appears in Fig. 19. The object of the brace is to increase the speed of the revolutions of the bits and also to obtain leverage. The brace consists essentially of a crank fitted with a handpiece and a chuck for holding the tools. The bits are inserted in the jaws of the chuck and held tight by a screwed ferrule.

Bits can be obtained in a variety of shapes and forms for various purposes. The shell-bit shown at A in Fig. 18 is used mostly for boring small holes for screws, etc.; while the centre-bit at B is employed for making larger holes.

Braces.—There are two forms of braces, namely the plain brace and the ratchet. The former is being rapidly replaced by the latter as the ratchet brace embraces the two. The ratchet device enables the crank to be turned without the chuck, a feature which makes it particularly convenient when working in confined positions. The bit can be driven in (or extracted) by a partial turn of the crank, which when swung back has no effect on the bit, due to the sliding action of the driving pawl over the ratchet. A good type of brace to acquire is one having about an 8-in. sweep and fitted, of course, with the ratchet device.

The Centre-bit consists of a centre pin which guides the tool when cutting the hole, a nicker which severs the fibres of the wood, and a cutter which removes

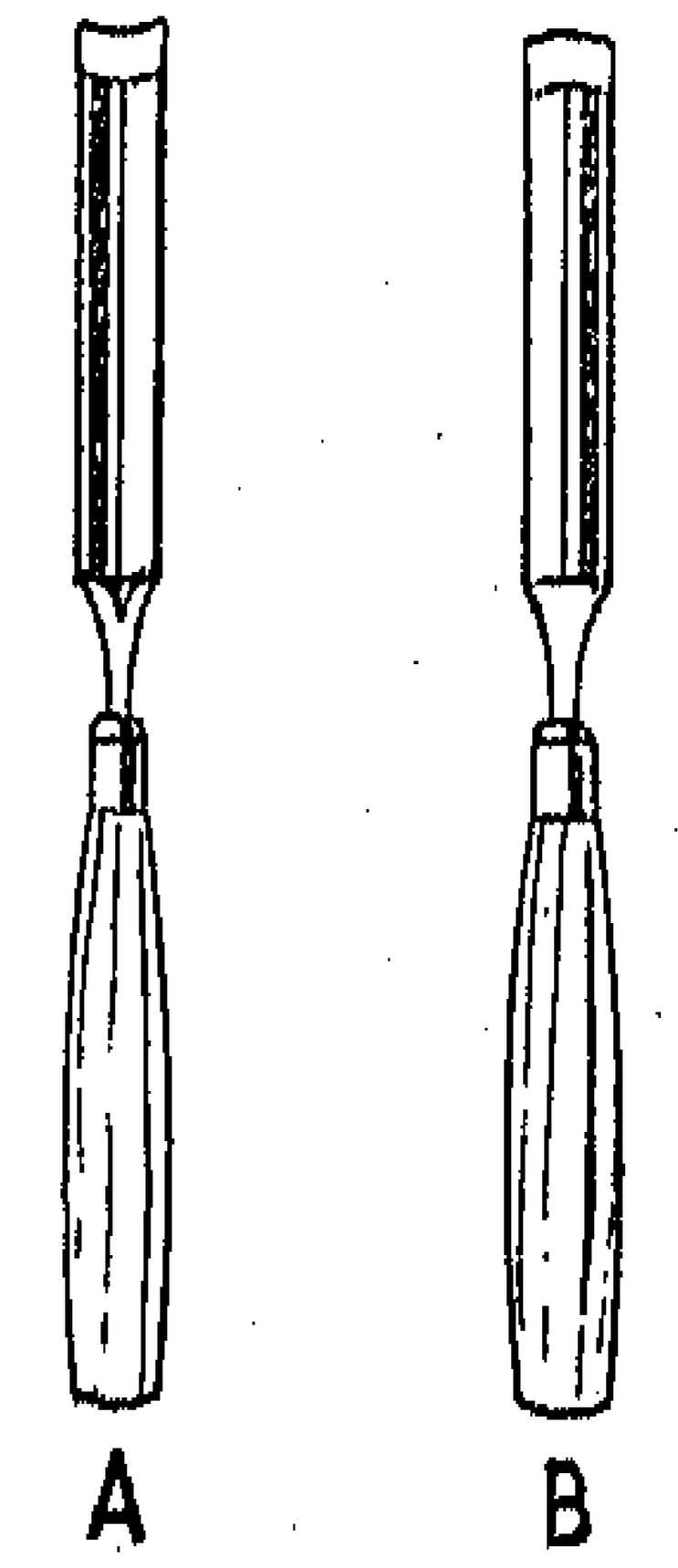
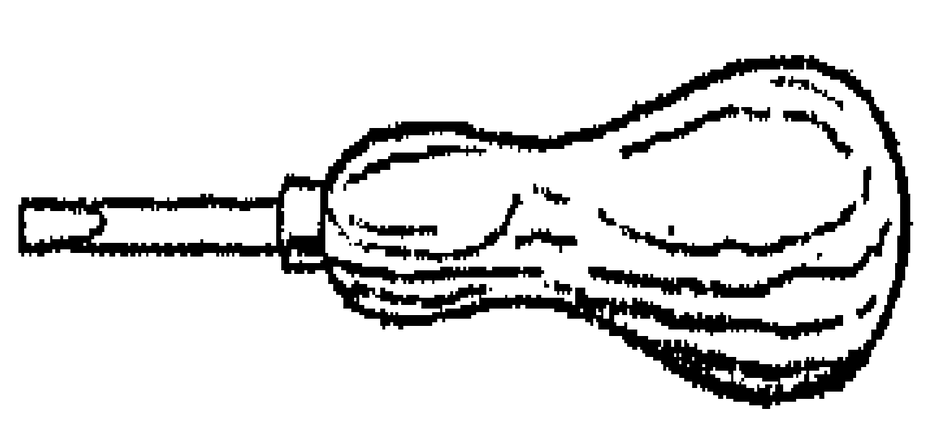


FIG 14



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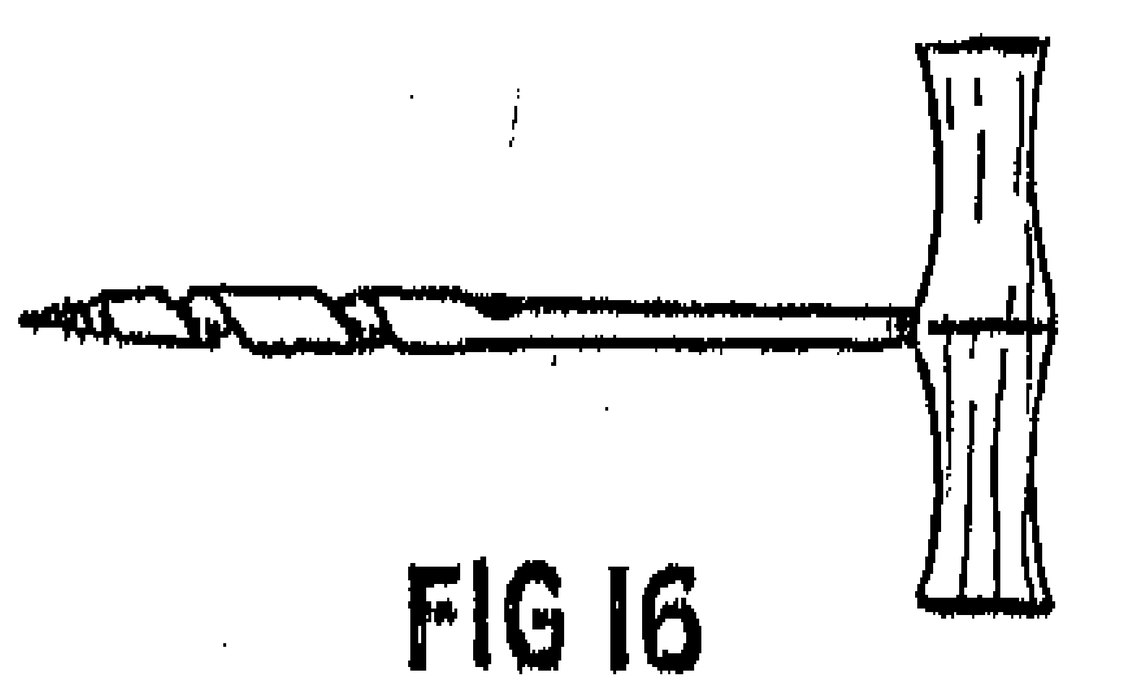
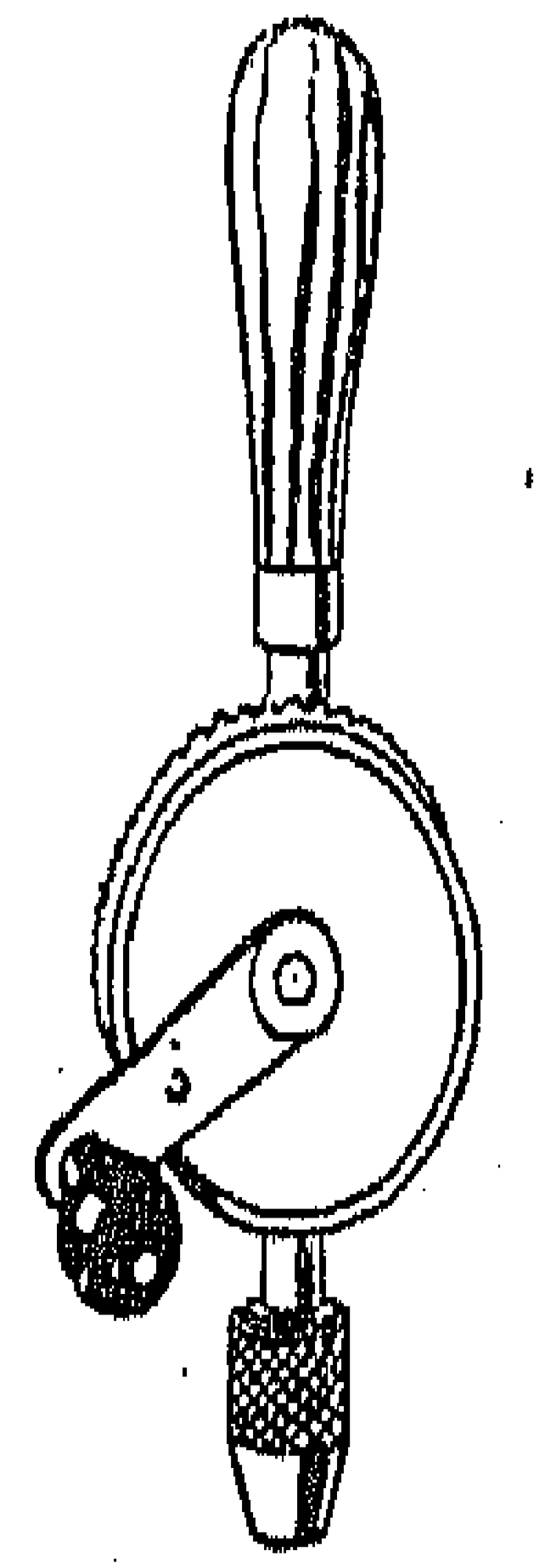


FIG 16



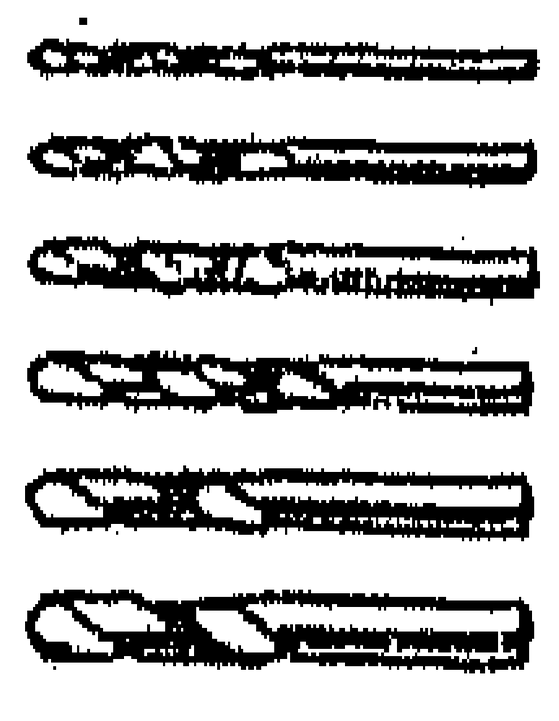


FIG 17

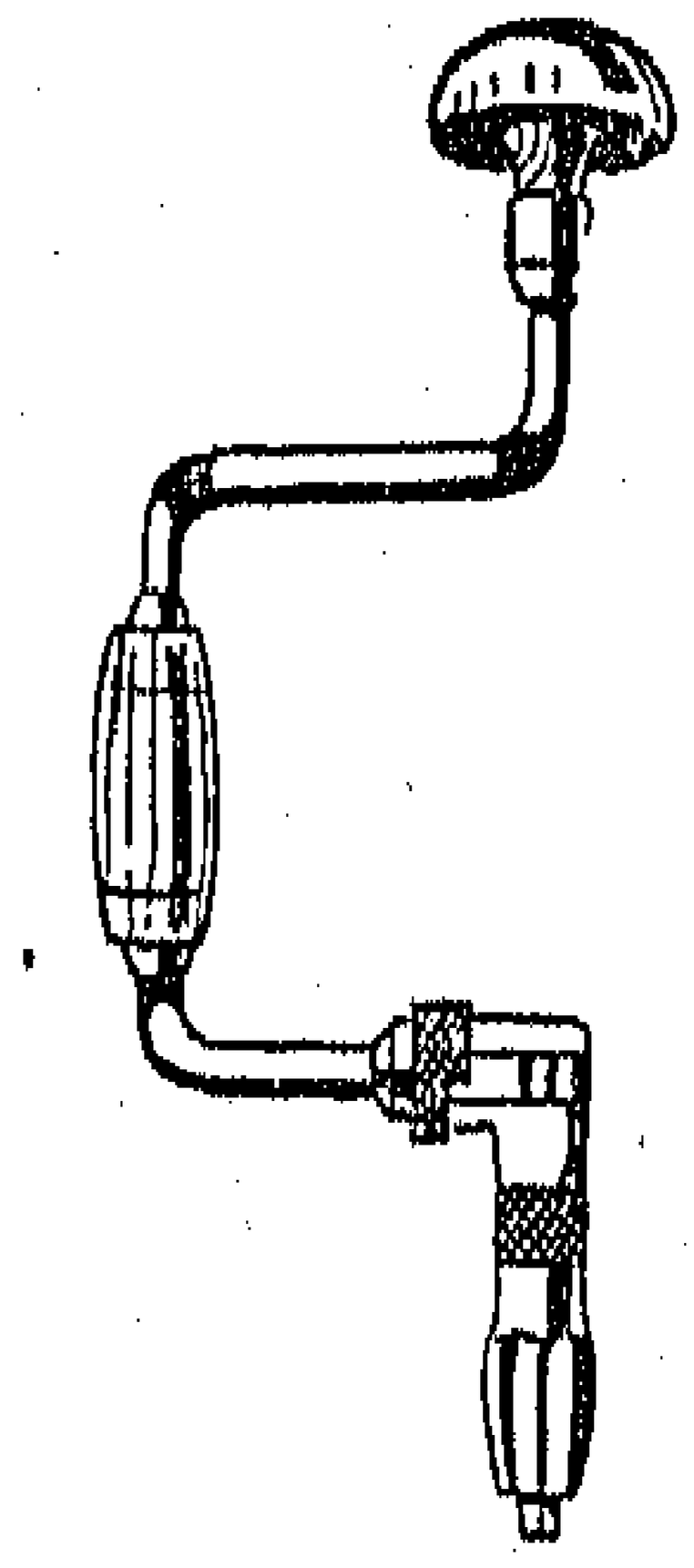


FIG 19

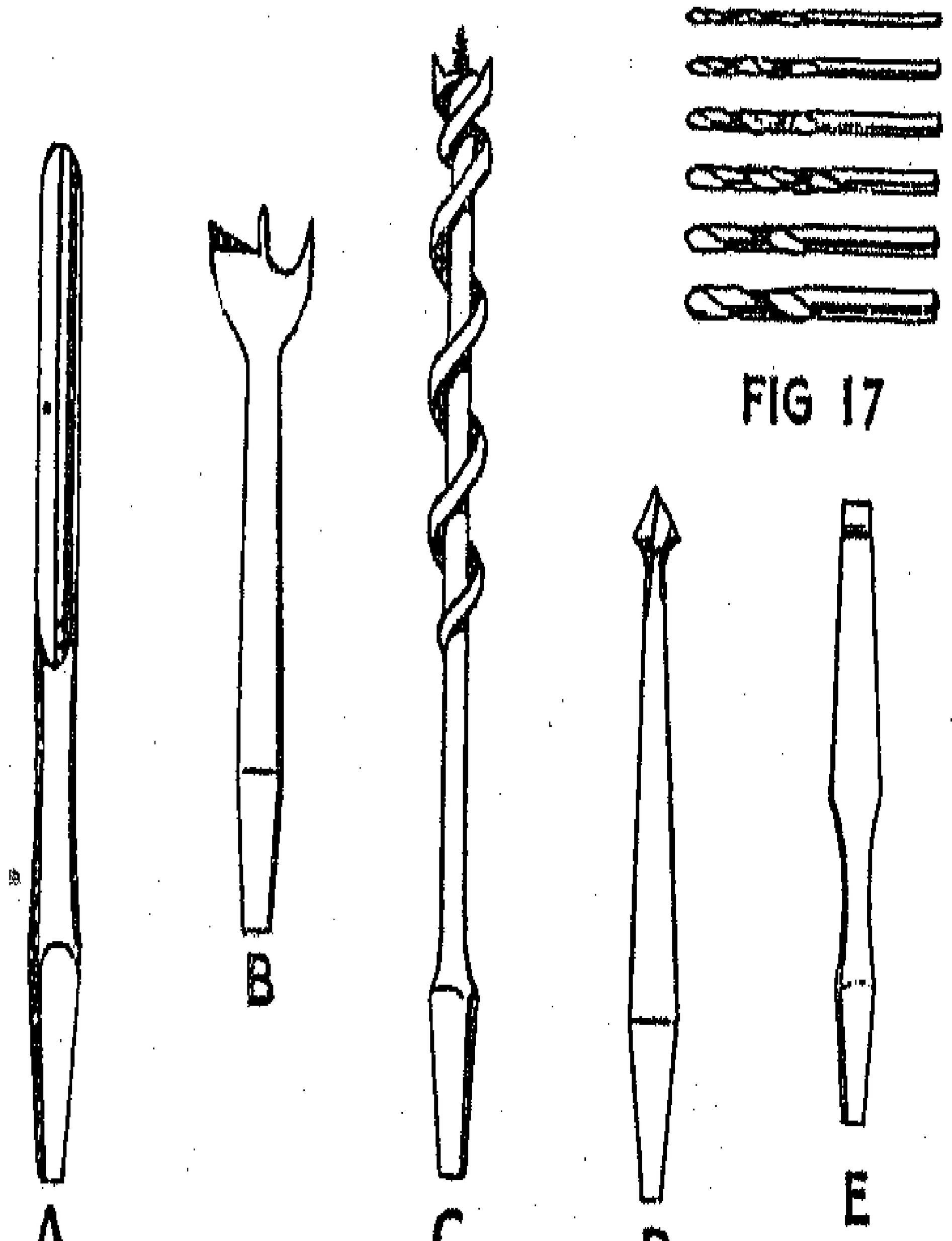


FIG 18

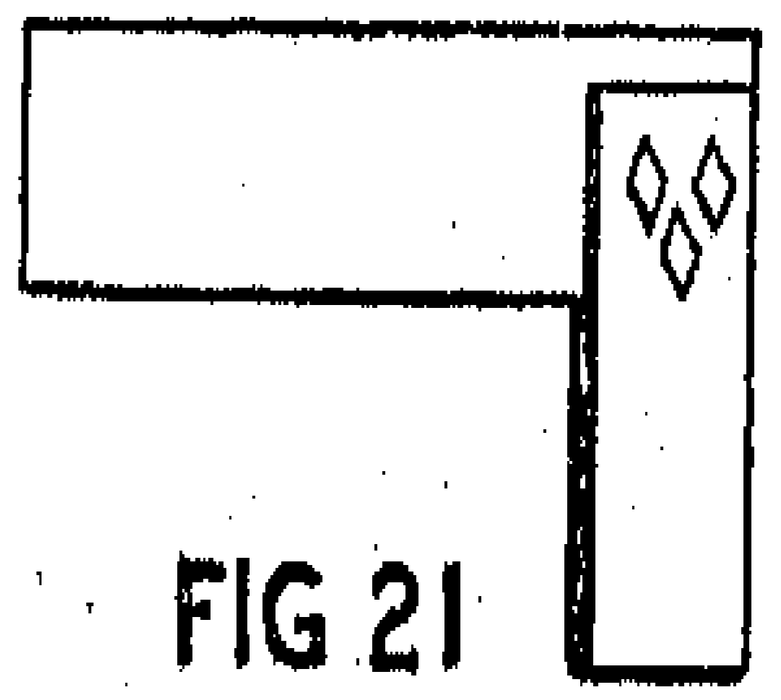


FIG 21

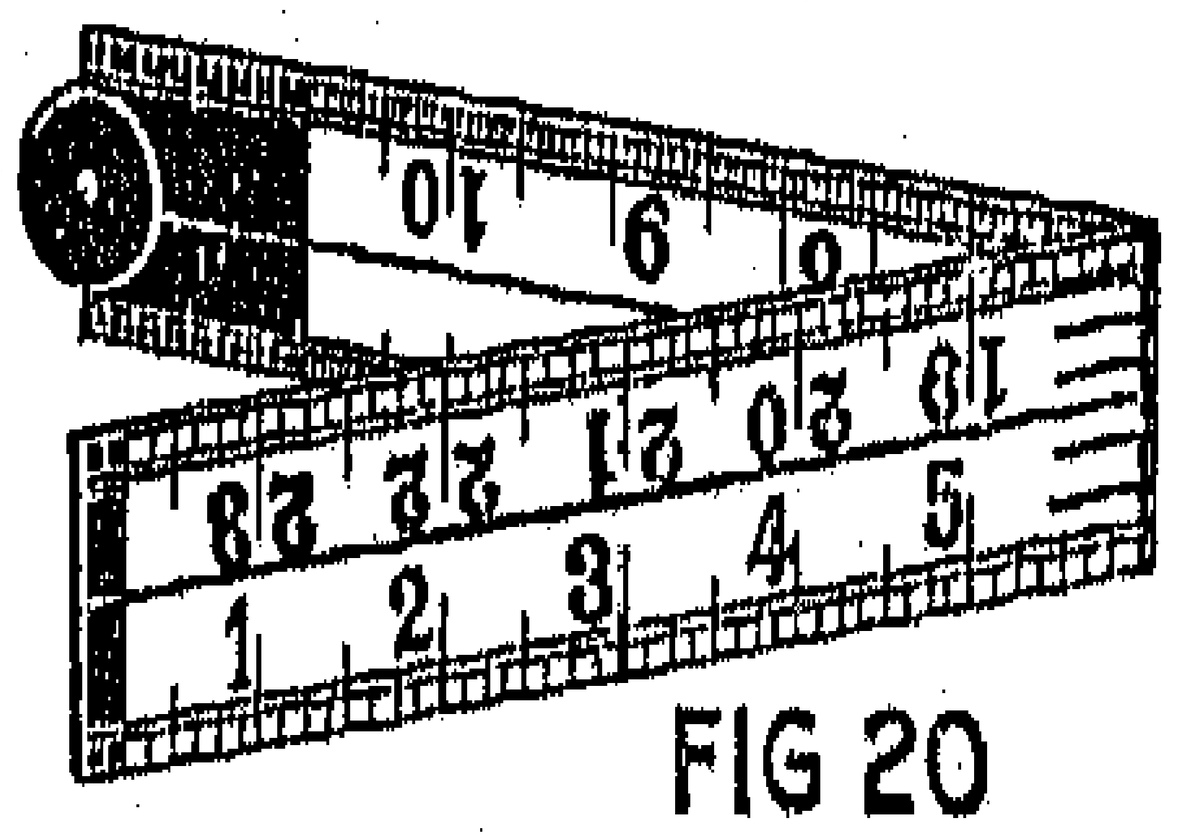


FIG 20

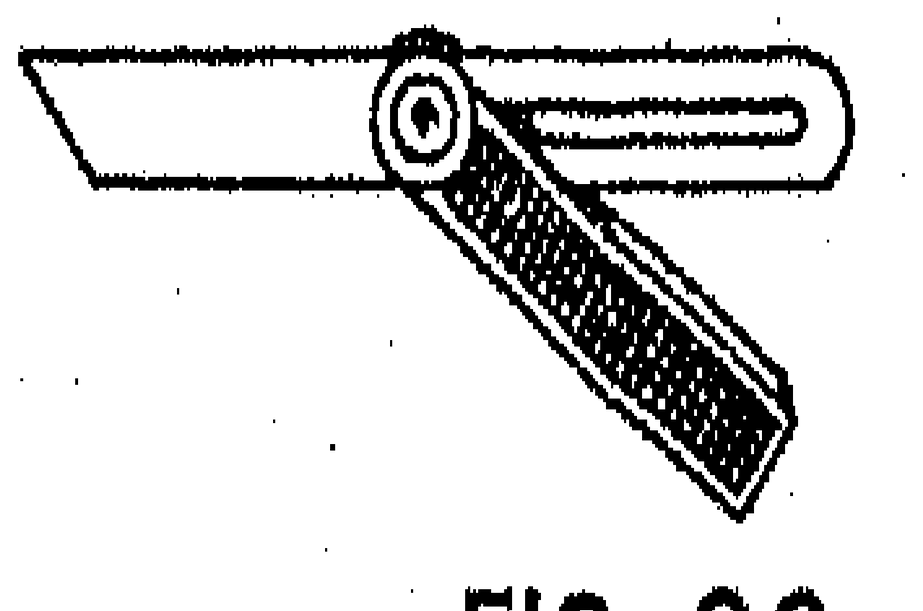


FIG 22

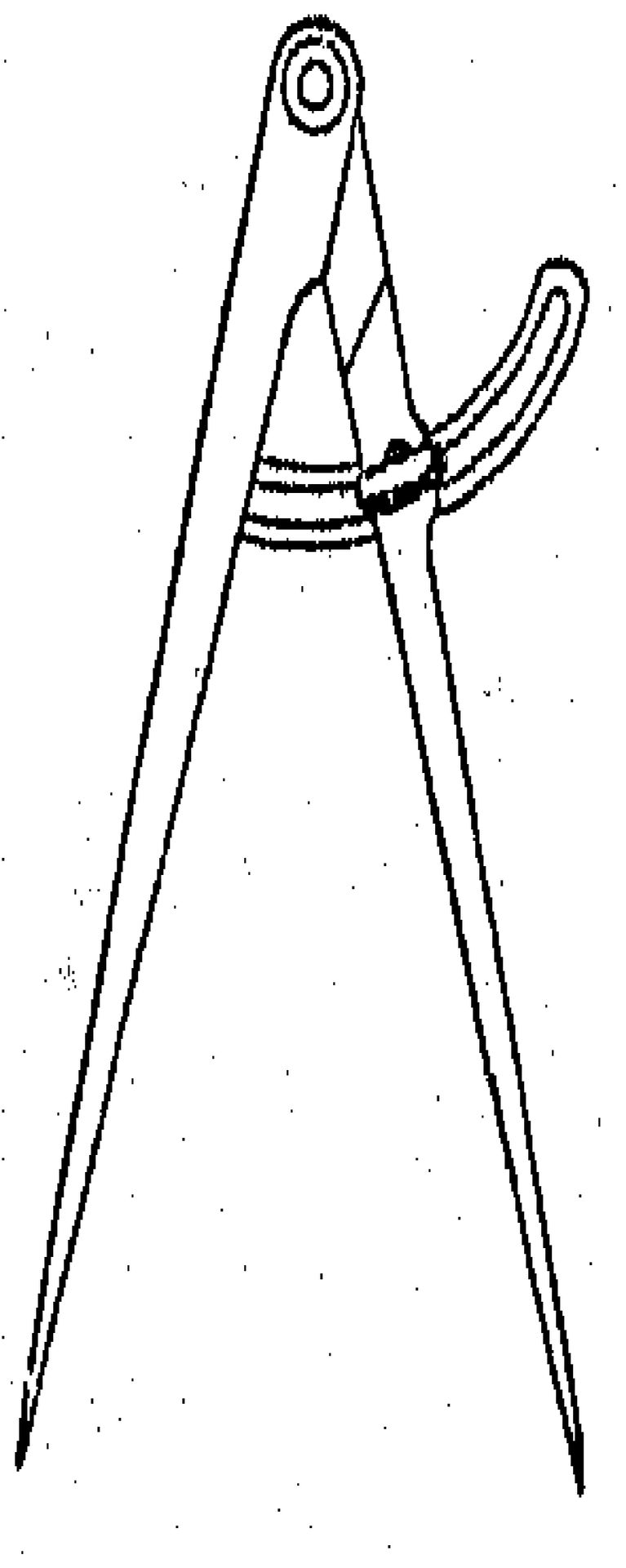


FIG 25

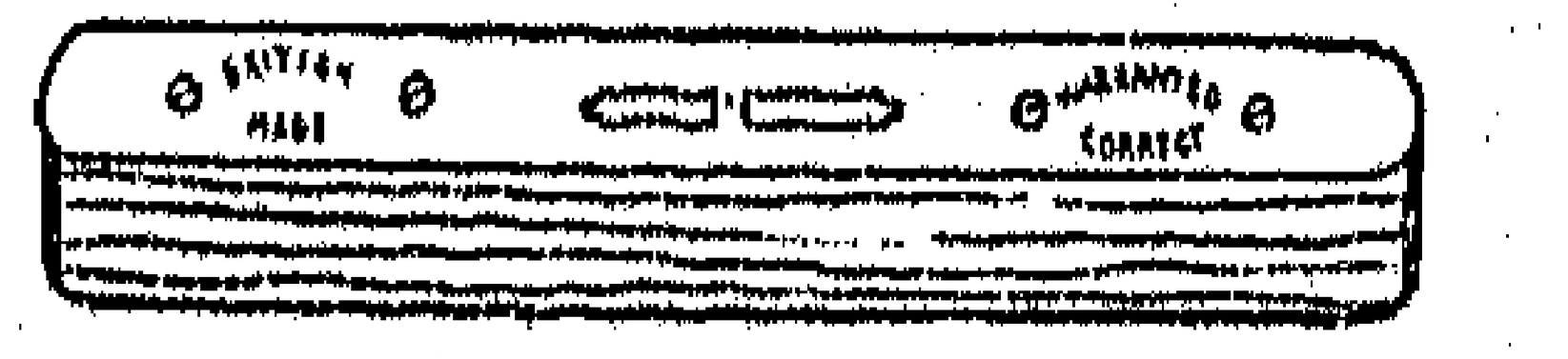


FIG 26

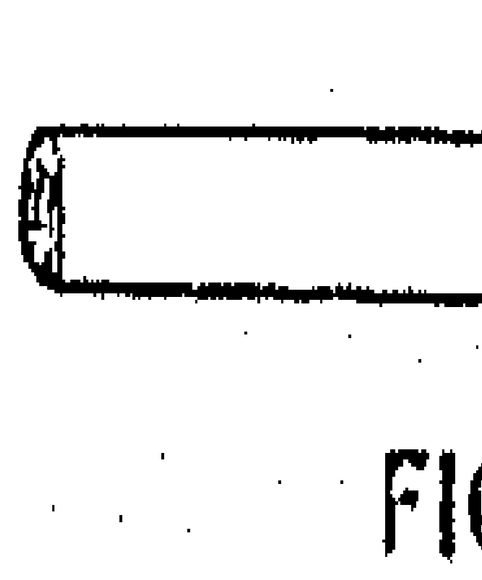


FIG 23

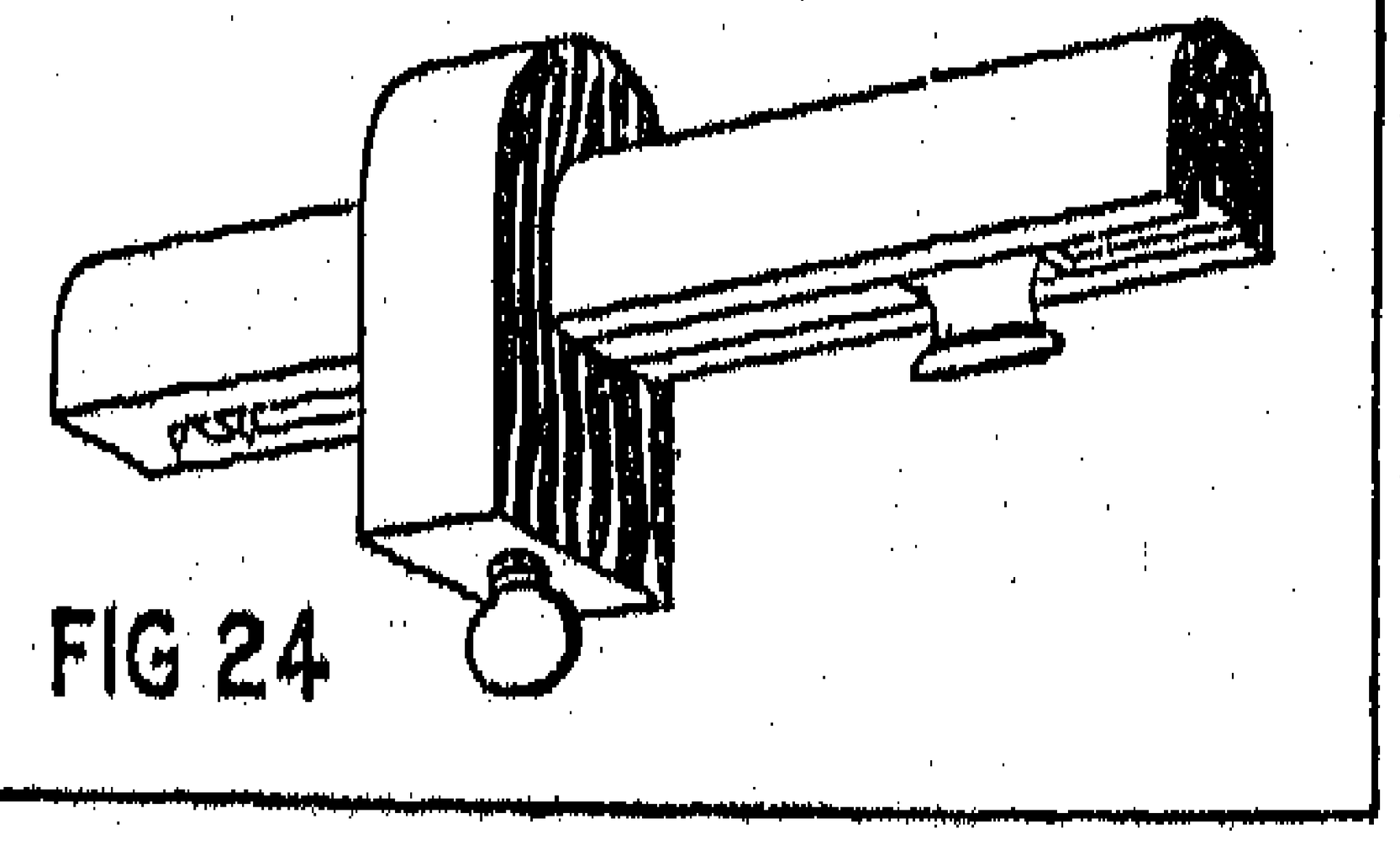


FIG 24

the waste. A centre-bit is used principally for making shallow holes, and makes a clean hole when sharp. When using this type of bit the work should be placed upon a piece of flat wood and the hole partially made until the point of the tool just appears at the back of the work. The work should then be reversed and the operation completed from the other side.

The Twist-bit is a very useful type of boring tool, and is illustrated at C in Fig 18. It is provided with a screwed tapered point, similar to that at the end of a gimlet, while the body of the tool is helical-shaped. When the boring operation is started, the screwed point draws itself into the wood and the cutter does its work without any perceptible pressure being applied at the top of the brace. Twist-bits can now be purchased quite cheaply, so it behoves the woodworker to include $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ and 1 in. bits in his collection.

A Countersink-bit is used for removing the sharp edge of a screw hole to enable the head of the screw to lie flush with the surface. This tool is obtained in two forms. One called the snail-horn (as shown at D) is used for countersinking soft wood. The other, known as the rose or fluted head, is employed for hardwood.

A Screwdriver-bit (E) is another useful tool. In addition to its value in driving in screws it is also useful for removing obstinate ones, made possible by the extra leverage obtained by the brace.

Rule.—Among the many measuring tools employed by the woodworker the four-fold "two-foot" rule (illustrated in Fig. 20) is perhaps the most popular. It is hinged in three parts, which enables it to be conveniently carried in the pocket. A graduated scale in inches and fractions of an inch is engraved along each edge. Some rules are provided with a brass sliding piece with a projection at the outer end to enable the thickness of wood or the diameter of a screw to be easily gauged.

Try-square.—Fig. 21 shows a try-square used for marking work at right-angles. It usually consists of a blued steel blade riveted to a hardwood stock, the inner edge of which is faced with brass.

Bevel.—Another tool of a similar nature is the adjustable bevel (illustrated in Fig. 22). It consists essentially of a light hardwood stock, slotted at one end to take the blade, which is fastened by a clamping screw passing through the stock and the slot in the blade. This arrangement enables the blade to be set to any desired angle.

The Marking-gauge (Fig. 23) is used for marking lines or points parallel to the edge of the work. In its commonest form it consists of a hardwood bar about 9 in. in length, with a movable block sliding along it and fixed in position by a screw. The pointed end of a steel pin projects on the flat face at the end of the bar, which marks the work when the block is held in position and pushed along the edge. As the spike is often some appreciable distance from the end of the shank and therefore prevents its use for certain operations, it is advisable to get two gauges so that the end of one can be cut off close to the pin. This will be found extremely useful, for instance, when fitting hinges in awkward places.

The Mortice-gauge (as shown in Fig. 24), really a double marking-gauge, is constructed similarly to the marking-gauge. It is provided with two pins, one of which is adjustable to allow it to be set at any desired distance within its limits from the fixed pin. It is used when two parallel lines are required to be marked on the face of work when setting-out mortices and tenons, etc.

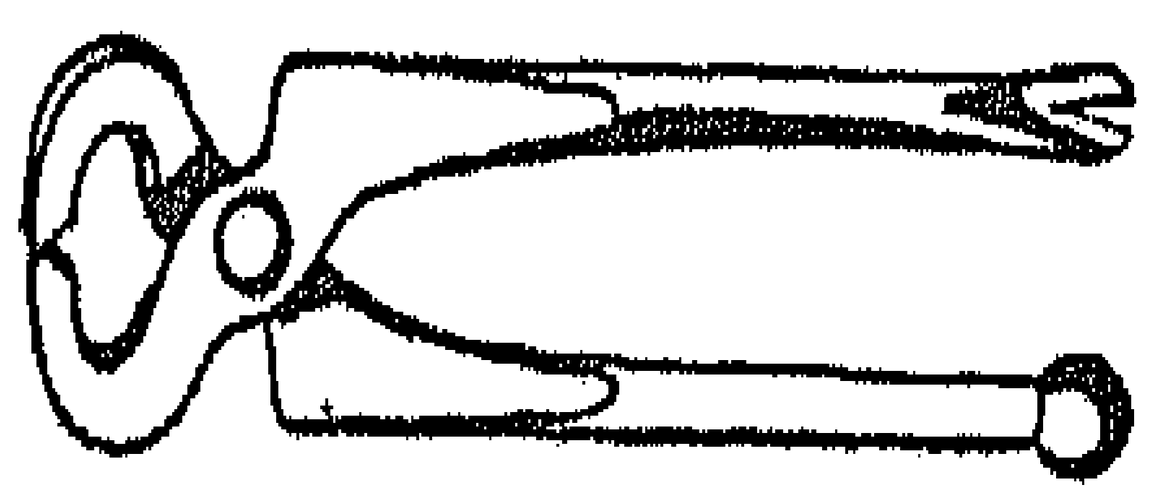


FIG 28

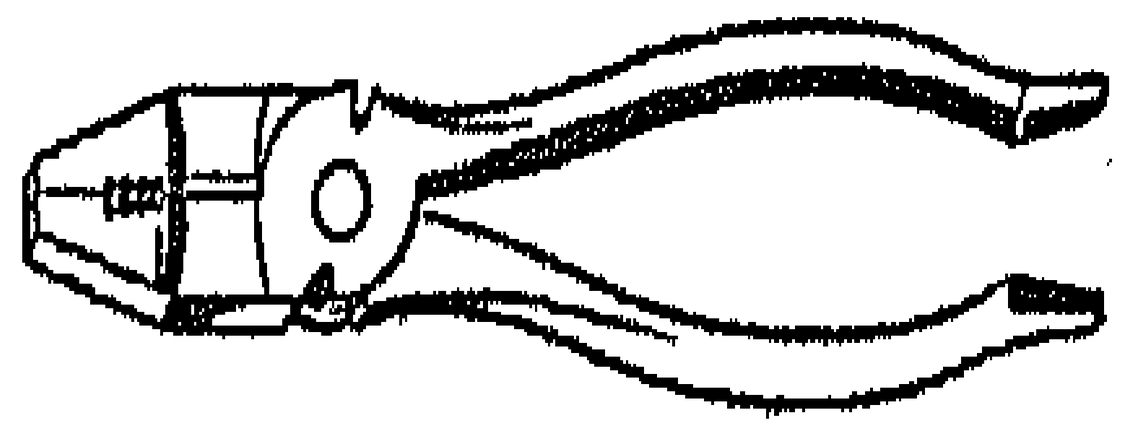


FIG 29

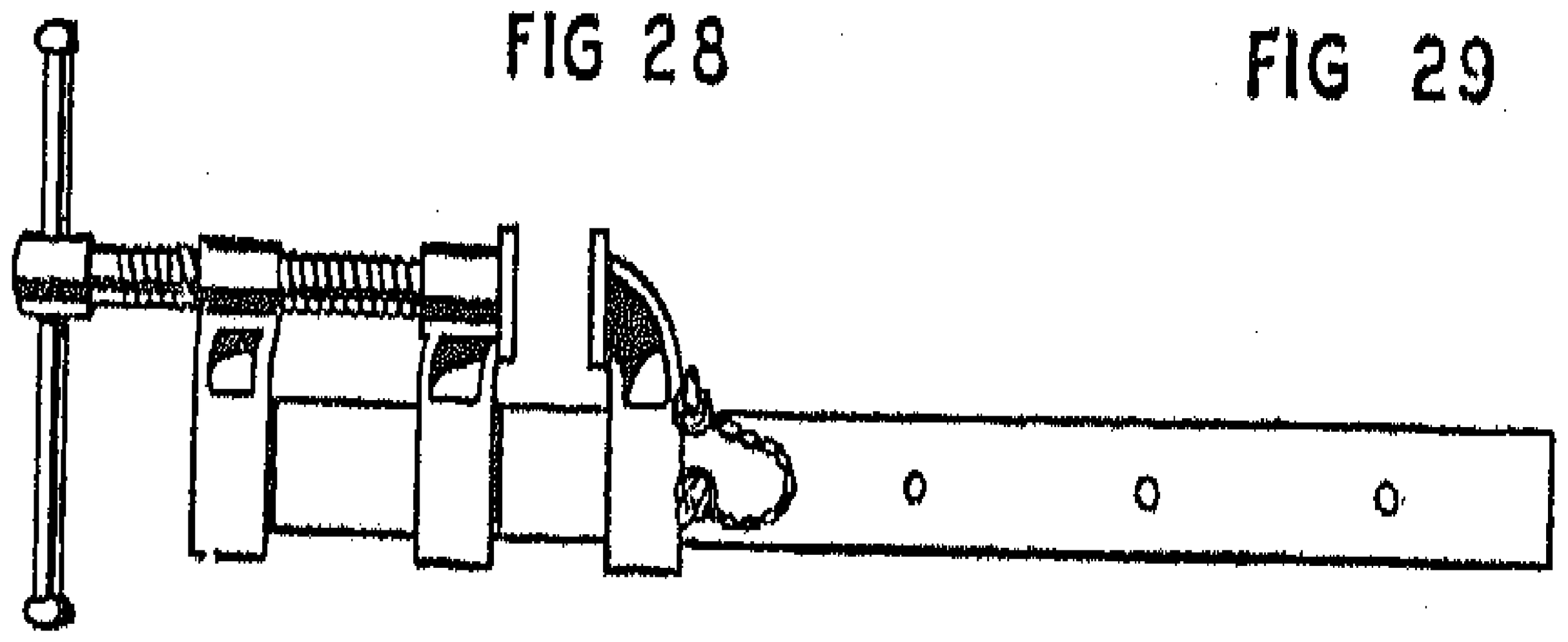


FIG 30

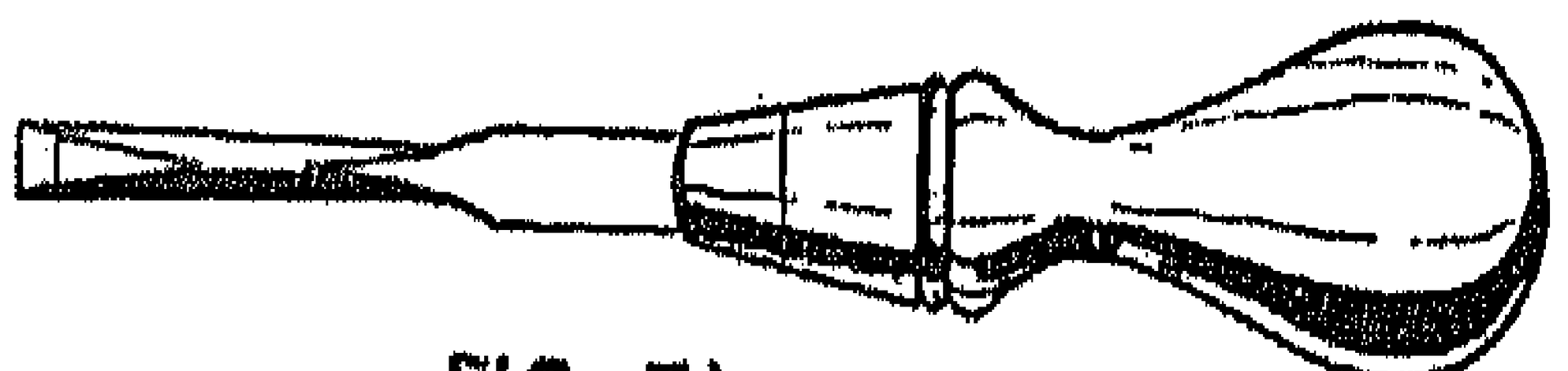


FIG 31

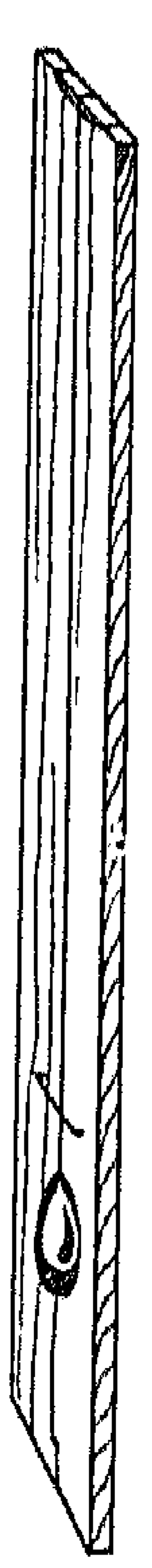


FIG 27

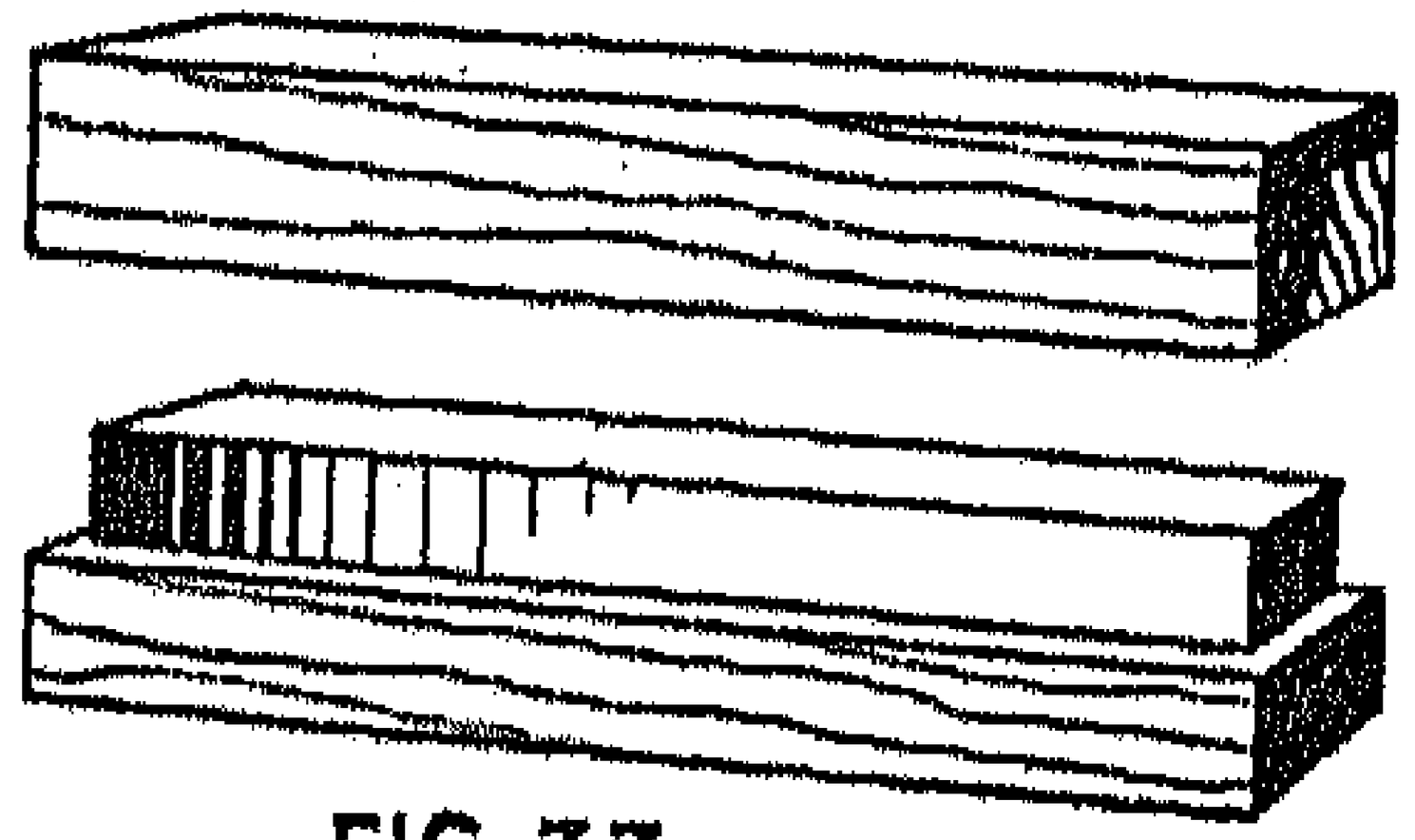


FIG 33

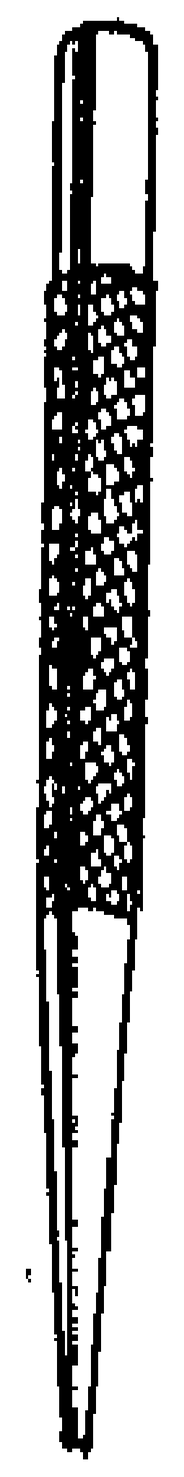


FIG 32

A Cutting-gauge is a tool similar to the marking-gauge, except that a cutting-edge takes the place of a pin. The cutter is held in position by a brass wedge to allow the depth of the cutter to be altered. The tool is handy for cutting thin strips of wood along the grain.

Dividers are used for several purposes, such as striking curves, transferring measurements from the rule to the work, marking out equal distances along work, etc. Fig. 25 shows a good type of dividers where to one leg is attached a quadrant, through a slot in which passes a screw on the other. When the legs are opened to the desired distance, a turn of the screw in the second leg presses upon the quadrant and locks them.

The Spirit-level (shown in Fig. 26) consists of a small glass tube containing methylated spirit set in a truly squared block of wood (sometimes metal), covered with a slotted brass plate exposing a short length of the tube. The plate is marked with a centre mark. When the instrument is placed on a truly level surface an air bubble appears which coincides with the mark. It is useful when fitting up shelves and other work where a truly horizontal position is required. When a long length of work is to be tested it is usual to interpose a length of trued-up wood between the work and the level.

Plummet-gauge.—Fig. 27 shows the plummet-gauge, used when it is required to fix a piece of work vertically, such as the uprights of a shed or garage. It consists of a metal plummet, a length of fine cord, and an accurately prepared strip of wood. A gauge-line is marked along the centre of the face, parallel with the sides, while the plummet is suspended by the cord from a saw-cut formed in the upper end of the rule and hangs freely in a hole made a few inches from the other extremity. In use, the long edge of the plumb-gauge is placed against the work, which is adjusted until the plumb-line coincides with the line on the rule.

Pincers.—Fig. 28 shows a pair of pincers commonly used for extracting nails. A good pair of pincers is made of forged steel. To prevent damage to the surface of the work a thin piece of wood should always be inserted between the tool and work.

Pliers.—Strictly speaking, pliers (Fig. 29) do not come under the category of woodworking tools, nevertheless such a tool should always be included in a woodworker's outfit. The tool is extremely useful for holding small articles and cutting wire, etc.

Iron Cramp.—Fig. 30 shows an iron cramp employed for drawing pieces of work together while gluing-up framing.

The Screw-driver (illustrated in Fig. 31) is used for turning screws. It takes many forms and sizes both with regard to the blade and handle. Many may be acquired in time, but for a beginning it is advisable to get one that corresponds as near as possible with the size of the slot of the screw used. If the end of the blade is larger than the screw-slot the wood round the screw-hole will be torn away. On the other hand, if it is too small, difficulty will be experienced in driving the screw home, and the edge of the tool perhaps destroyed. Ratchet screw-drivers are to be obtained at a reasonable figure, and have the additional advantage that they can be used in either a right- or left-hand direction as in the case of the ratchet brace.

Nail Punch.—One useful little tool which should not be overlooked is the nail punch—or nail set, as it is often called—shown in Fig. 32. It consists of nothing more than a tapered piece of hardened steel having a flat or a hollowed blunt point. It is used for sinking a nail below the surface of wood. If driven deeply, the hole is afterwards filled in with stopping, such as plastic wood.

Oilstone.—No tool equipment is complete without an oilstone for sharpening tools, an illustration of which appears in Fig. 33. It is used for producing a keen edge on cutting tools. There are several kinds of oilstone, among which Turkey, Arkansas, and Washita may be mentioned. The Washita stone, of medium hardness, is much favoured by professionals as it is close-grained, somewhat soft, quick cutting and produces a keen cutting-edge. A hard stone should be avoided, as it tends to polish rather than cut, and makes sharpening a tedious job. If the tool to be sharpened is badly chipped on its cutting-edge it should first be ground on a grindstone or an emery grinder; or, failing either of these, a coarse carborundum stone makes a good substitute. After grinding, the tool is finished on the oilstone after a few drops of thin oil have been applied to its surface. For general purposes, a stone about 9 in. by 2 in. by 1¼ in. should be obtained. Before being put into service the stone should be partially sunk into a solid block of wood about ½ in. wider and longer than the stone, and a neat lid made in the same way to exclude dirt and grit. As oil is needed, a suitable oil-can should be obtained for its reception.

SAWS AND SAWING

THE types of hand-saws used by woodworkers for general use include a rip-saw for cutting timber along the grain, a cross-cutting saw for sawing across the grain, a panel-saw for general purposes, a tenon-saw, generally used on the bench, a pad-saw for cutting curves, and several others for special purposes.

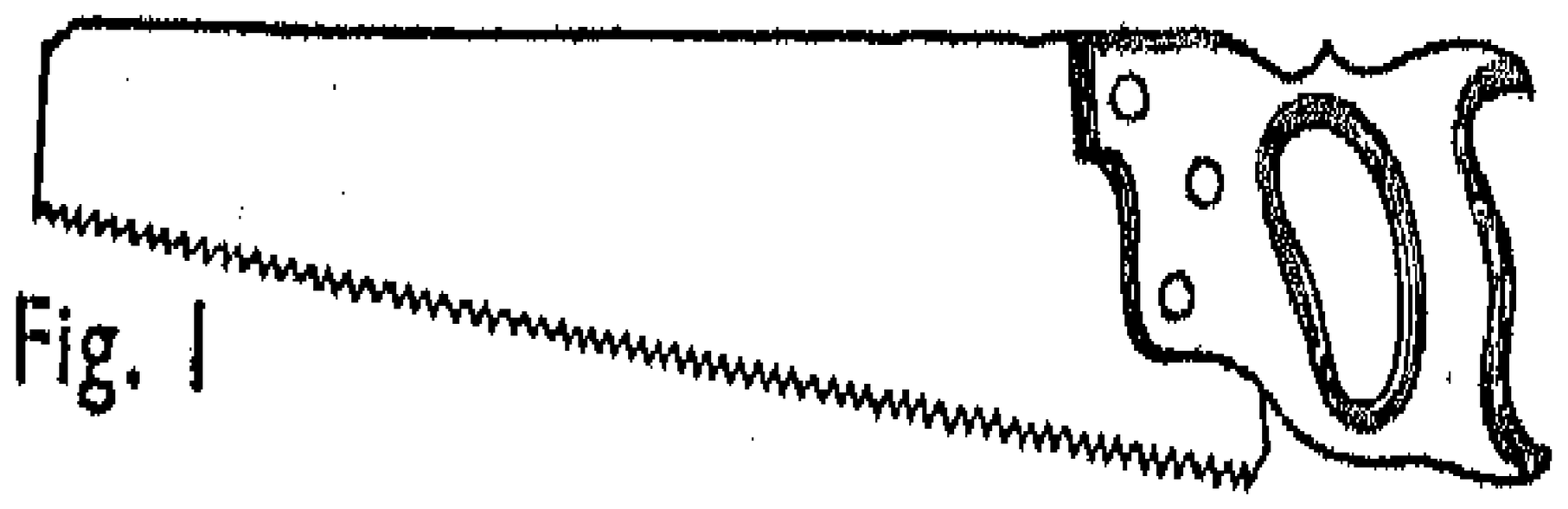


Fig. 1

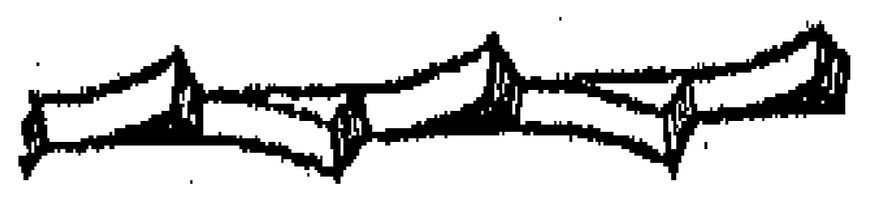


Fig. 2

Fig. 1 shows an illustration of a saw blade from which it will be observed that it consists of a thin tapered blade of hardened and tempered steel having a number of triangular serrations on its lower edge. These teeth, as they are called, act like a number of chisels or cutters which sever the fibres of the wood when the blade is moved through it.

If you now look at Fig. 2, which shows a few saw-teeth enlarged, you will notice that they are not in the same plane as the rest of the blade, but are bent out alternately one side and then the other. The amount of this bending out is termed the "set" of the teeth. You will also notice that the fronts or faces of the teeth are sloped off to form points instead of edges. The reason for setting the teeth is to allow clearance for the blade, for if this was not provided for the blade would simply bind in the work.

Rip-saws are used for cutting along the grain and not across it. The teeth of these saws are comparatively large and shaped as illustrated in Fig. 3, that is, the faces are usually at 90° to a line drawn through their tips, although in some intended for ripping softwood a slight amount of forward tilt is advisable. Rip-saws have four teeth to the inch in the usual practice for working softwood; while for hardwood a finer pitch of teeth is better—say, six to the inch, or even more.

Cross-cutting Saws are used for cutting timber across the grain and have a greater number of teeth to the inch compared with the rip-saw. For general purposes a saw having five to six teeth per inch is considered correct. The shape of the teeth is also different from the tool used for ripping. The faces of the teeth are set back, the amount depending upon the kind of wood to be operated upon. The harder the wood the more back slope is required. The tips of the teeth terminate in a fine point, due to the face and back being bevelled.

The correct way to hold such a saw is shown in Fig. 4, that is, with the forefinger extended along its handle and not through it, as seems the natural way of gripping the tool. This method is used to ensure control over the saw and accuracy when cutting along a guide line.

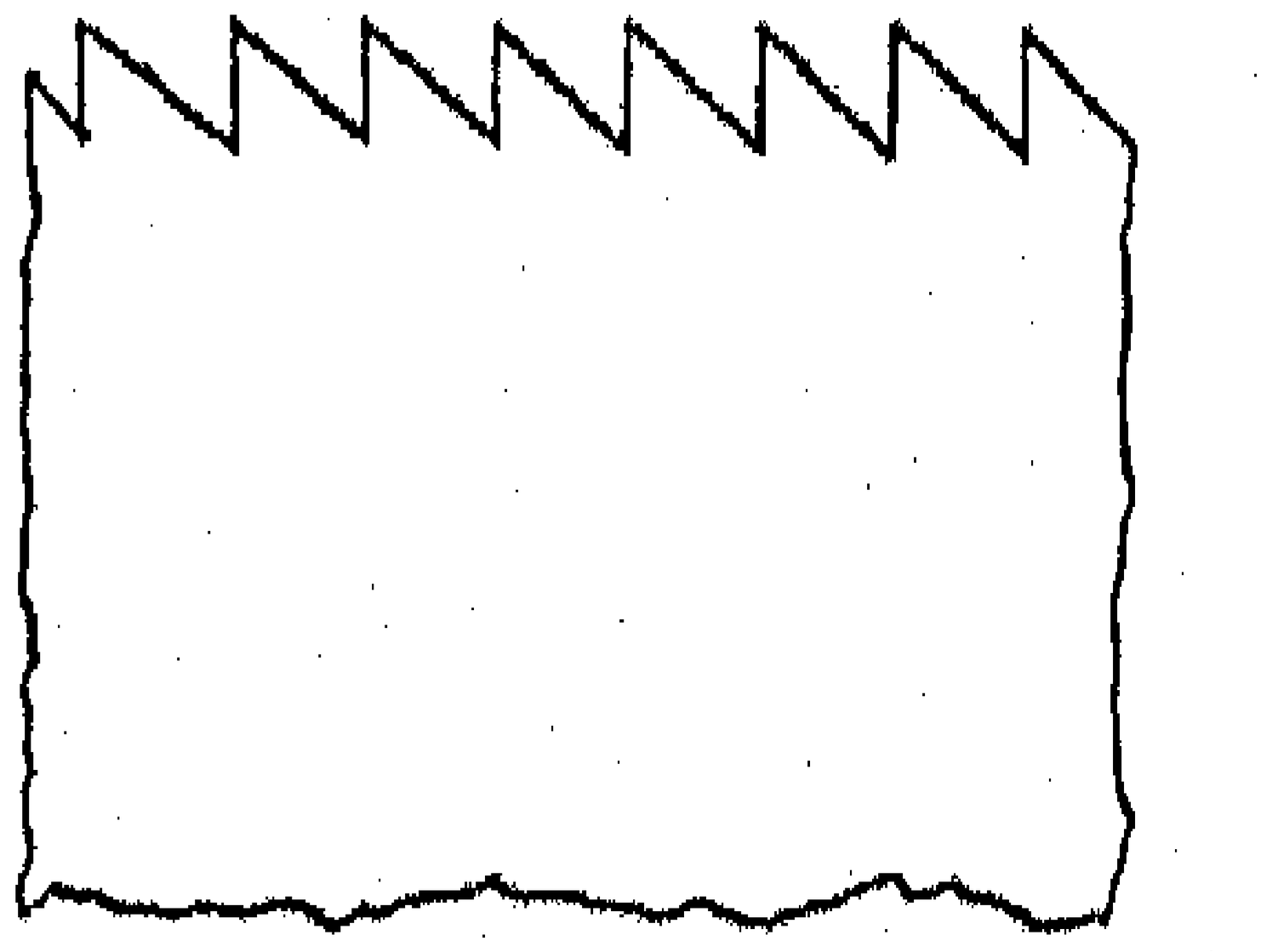


Fig. 3

To saw correctly only comes with practice. The chief difficulty to over-

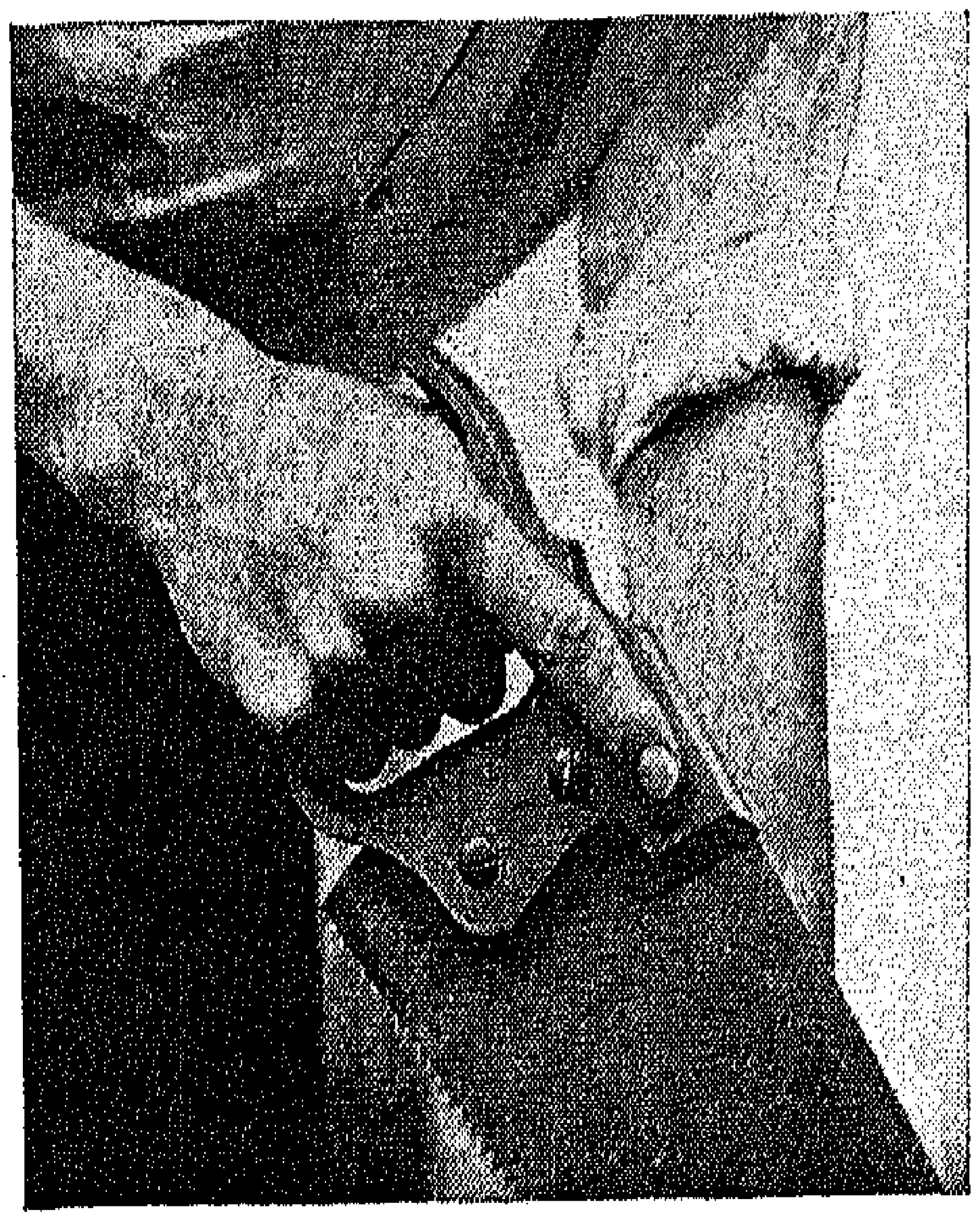


Fig. 4

come is that of keeping the saw square to the timber throughout the cut. Learn to cut squarely, and test with a square from time to time until you become proficient. Use as long strokes as possible and avoid sawing too quickly. A saw in good condition, that is, sharp, unbuckled, and correctly set, does not require pressure on the downstroke, so let it work by its own weight, simply pulling the saw slowly upward and pushing it slowly forward in long, even strokes. For easy cutting the saw should be nearly vertical.

Ripping.—When ripping, the board should always be supported on both sides of the cut to prevent the unsupported side from breaking off. A short board may either be laid along a sawing-trestle, or sawing-horse as it is sometimes called, with the end to be sawn overlapping the end of the trestle, or held in a vertical position in the bench vice, as shown in the illustration (Fig. 5). Start the cut by using the left thumb as a guide, as shown in Fig. 6, and push the saw blade very lightly against the wood so that it just nicks it, then continue until the slot is sufficiently deep to guide the saw. Keep the head well over the tool so that both sides can be seen. Move the saw to and fro in a vertical plane, taking care to keep the cut parallel to the mark, not forgetting to leave sufficient waste for planing to size afterwards if this is necessary.

If the board is to be sawn into two or more equal widths, follow the marked lines so that the saw-cut divides the line equally on each side.

It sometimes happens that the saw does not follow the line, in which case give the saw a slight axial twist on the downstrokes until the desired result is obtained. Do not attempt to bend the saw blade over towards the line as such a procedure is useless.

One of the faults common to novices is that they try to saw far too quickly and do not use sufficiently long strokes. This is bad practice, as short strokes mean that some of the teeth are not doing their proper share of cutting, and are thus caused to wear unevenly.

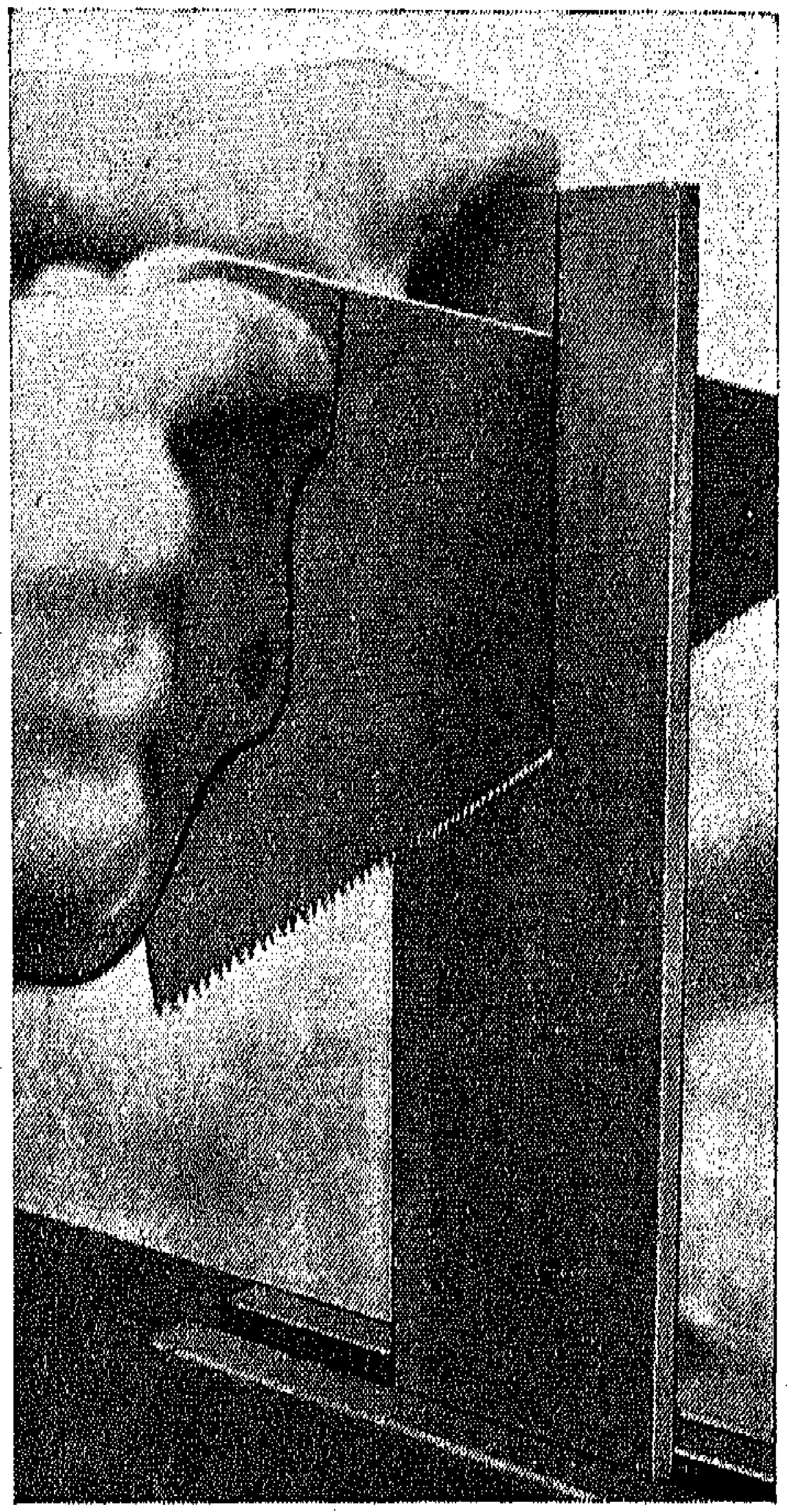


Fig. 5

It frequently happens, especially when ripping a long board from end to end, that the saw-cut closes and pinches the saw. This difficulty may be overcome by inserting a thin wooden wedge or the blade of a bradawl and following the saw up with it, as shown in Fig. 7. The wedge should be removed before finishing the cut to prevent the wood splitting.

Cross-cutting, or cutting across the grain of the wood, is not a difficult operation provided the cut is started in the right way. To do this, use the thumb as a guide for the blade in the same manner as in starting the rip-saw. Take two or three short upstrokes to get a start. Do not attempt to start on a downstroke as the saw is liable to jump, perhaps with disastrous results to one's hand.

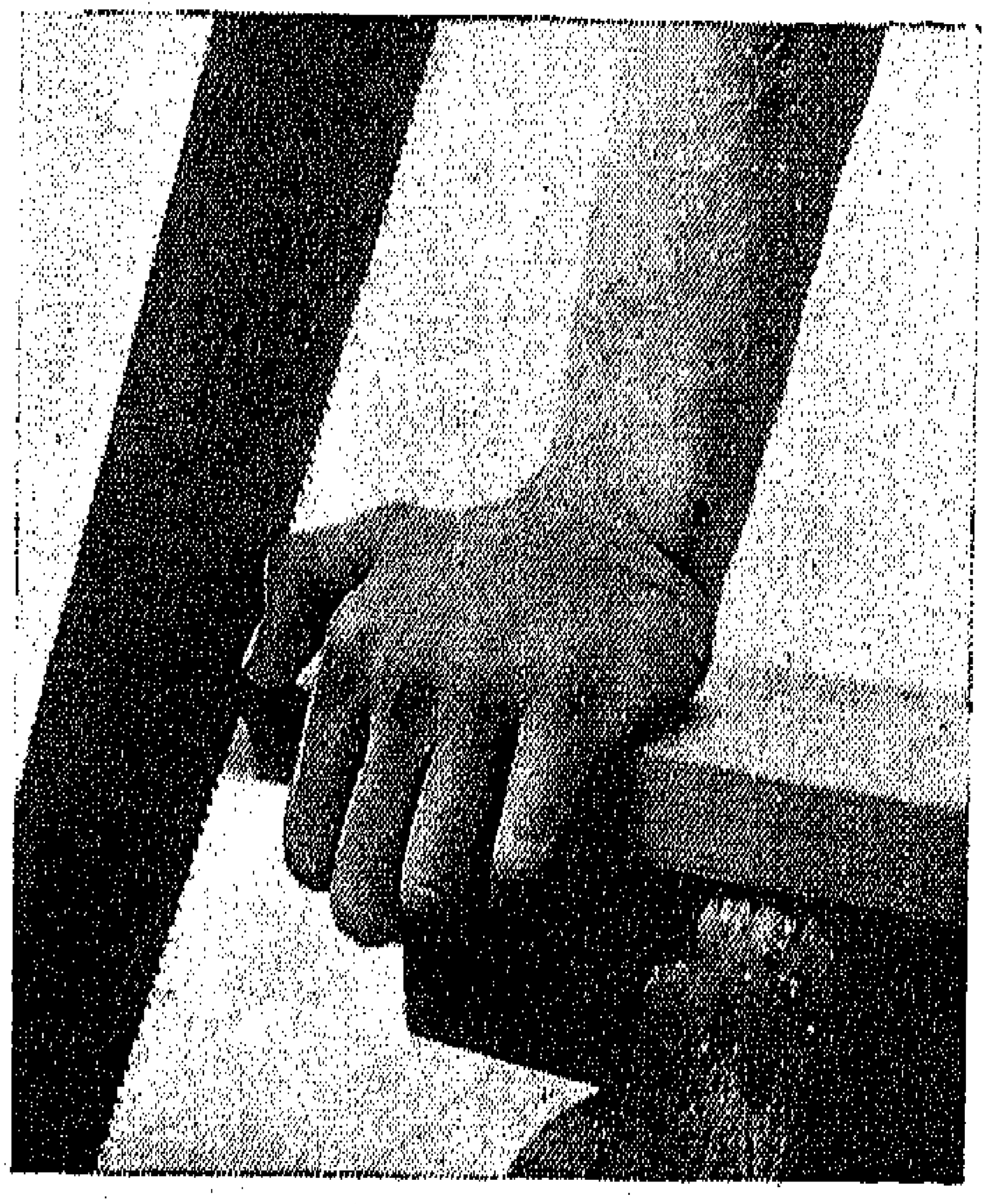


Fig. 6

To saw off the end of a board of given length, measure up the board and mark it with a pencil, guided by a square, to the desired size. If the board is a long one place the wood across two trestles—or boxes, if trestles are not available. Place the right knee upon the board to steady the wood. Start the cut just outside the line to allow sufficient waste for finishing off with a plane. The left hand can now be used to help support the board. Cut across the wood, using long even strokes until near the end of the cut, when the strokes should be very light to prevent spoiling the edge.

If the amateur does not feel disposed to go to the expense of purchasing a rip-saw and a cross-cutting saw, the best equivalent to have is a panel-saw. Such a saw can be used for ripping, cross-cutting and, in a good many instances, for cutting wood where a tenon-saw would be normally employed. It is not, however, so efficient as the separate tools. A handy size to have is one with a 22 in. blade.

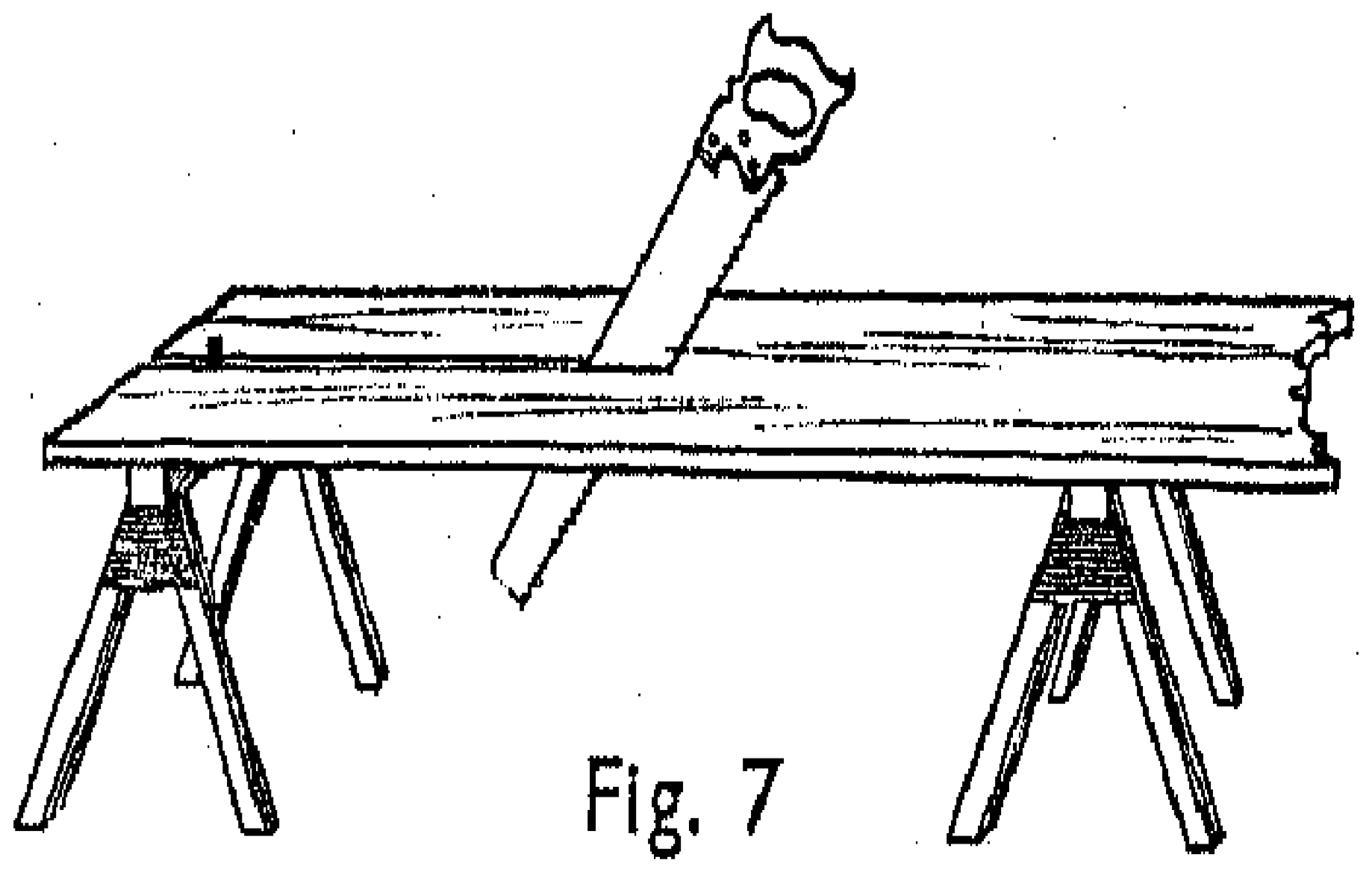


Fig. 7

The Mitre- or Tenon-saw shown in Fig. 8 is a different type of tool from either the cross-cut or rip-saw, the blade being parallel and very thin. The upper edge is provided with a stiffened back of either brass or steel which somewhat restricts its use. The teeth are very much finer and more numerous, varying from 10 to 14 to the inch. It is usually employed on work held in the vice, or across a bench-hook, an illustration of which appears in Fig. 9. The bench-hook is a simple device for holding the work steady. It consists essentially of a flat piece of wood having

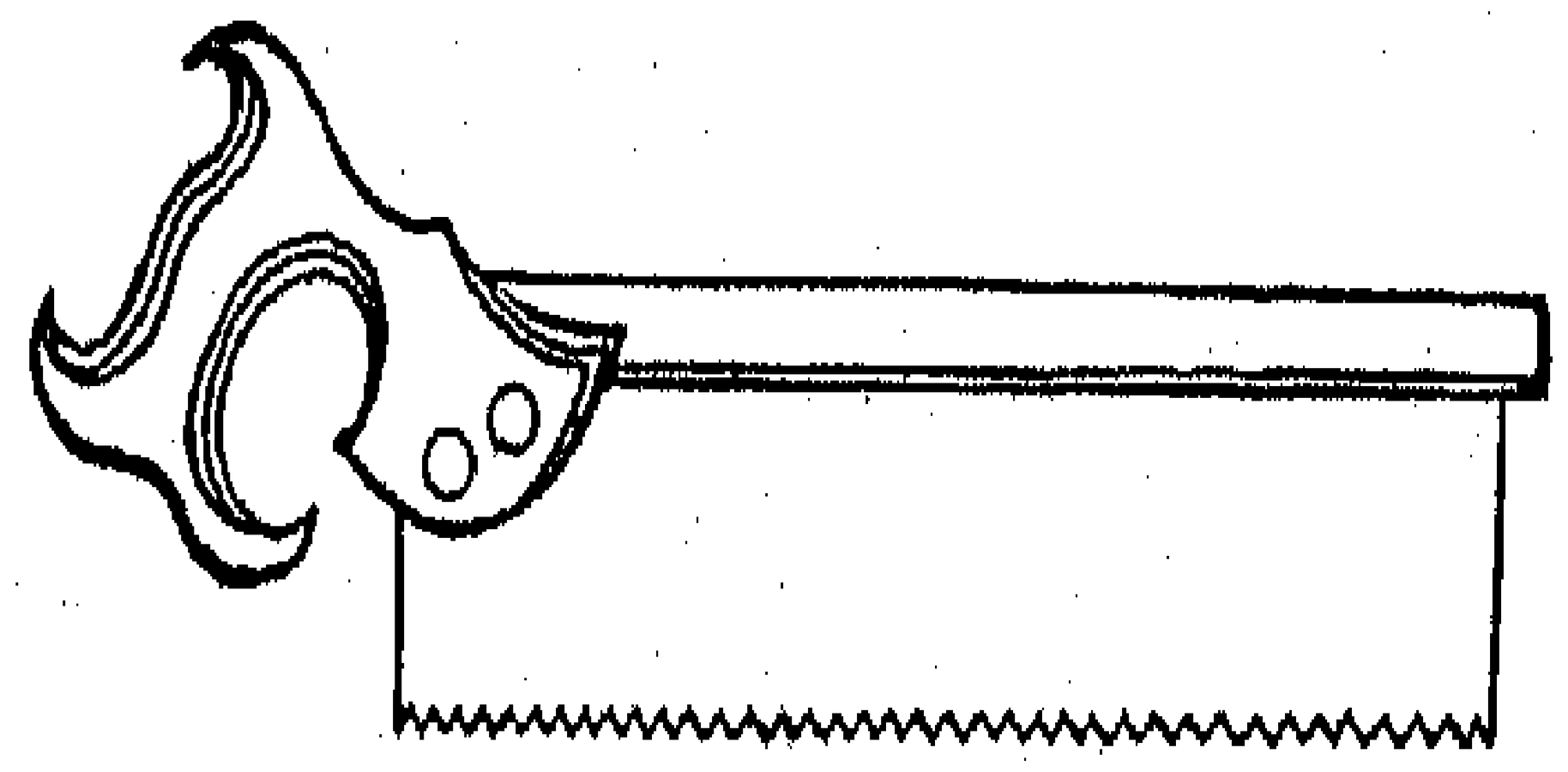
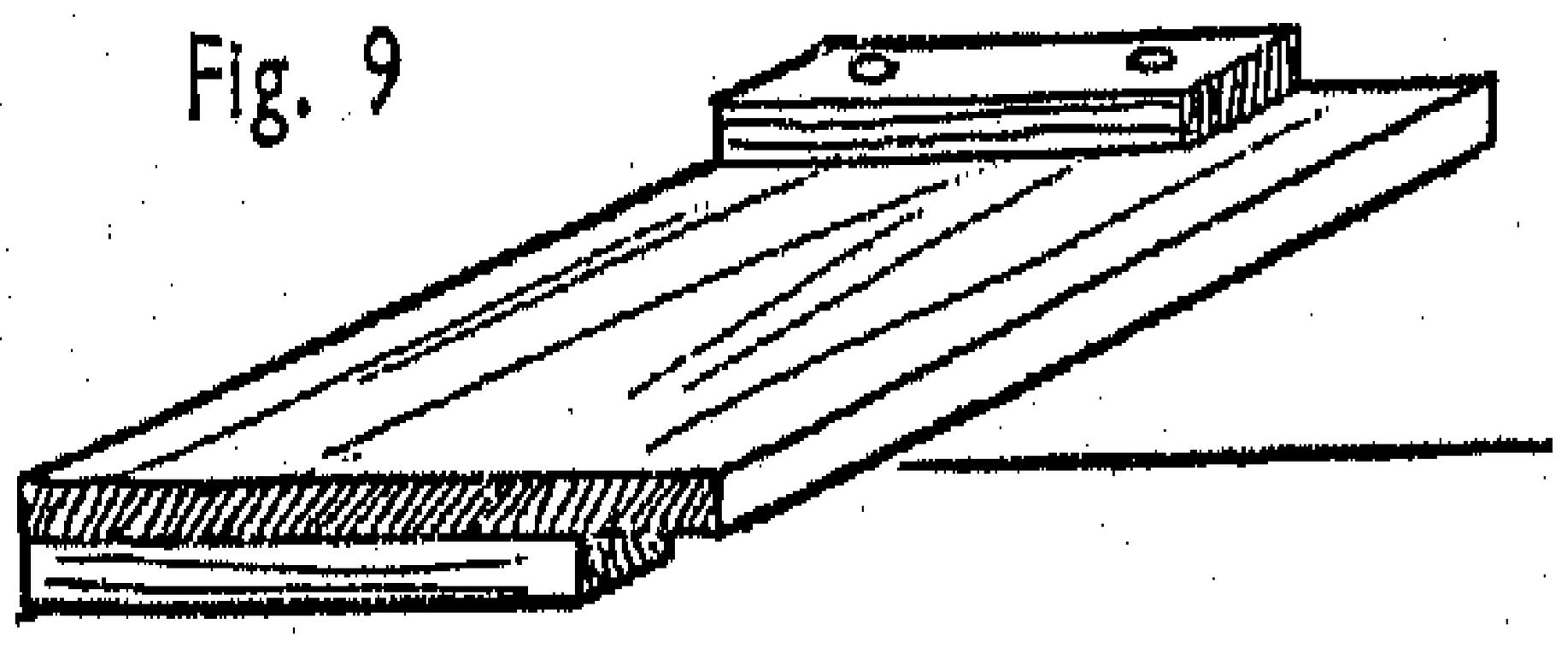


Fig. 8

a wooden block at the back edge of the top and a similar block fixed on the underside along the front edge. When a piece of wood is to be sawn, the bottom block of the bench-hook is placed against the front edge of the bench, and the material placed and pressed against the top with the left hand. The correct way to saw, when using the hook, is to start cutting with the saw gripped in the right hand with the index finger extended in the same way as the rip-saw is held, and the blade tilted up to an angle of about 30°, and as the sawing proceeds, gradually to bring the handle down until the saw is horizontal. An illustration of a bench-hook in use is seen in Fig. 10.

Fig. 9



The tenon-saw is also used with a mitre-block for cutting mitres, etc. For small work the mitre-block shown at A in Fig. 11 is employed, while for larger work a mitre-box illustrated at B is the correct accessory to use. The mitre-block is somewhat similar to the bench-hook, the main difference being that the back block is provided with three vertical saw-cuts or slots, two at angles of 45° and the other of 90°, which serve as guides for the saw. The two angled slots are set in opposite directions for cutting mitre-angles, while the centre slot enables work to be cut perfectly true, at right-angles.

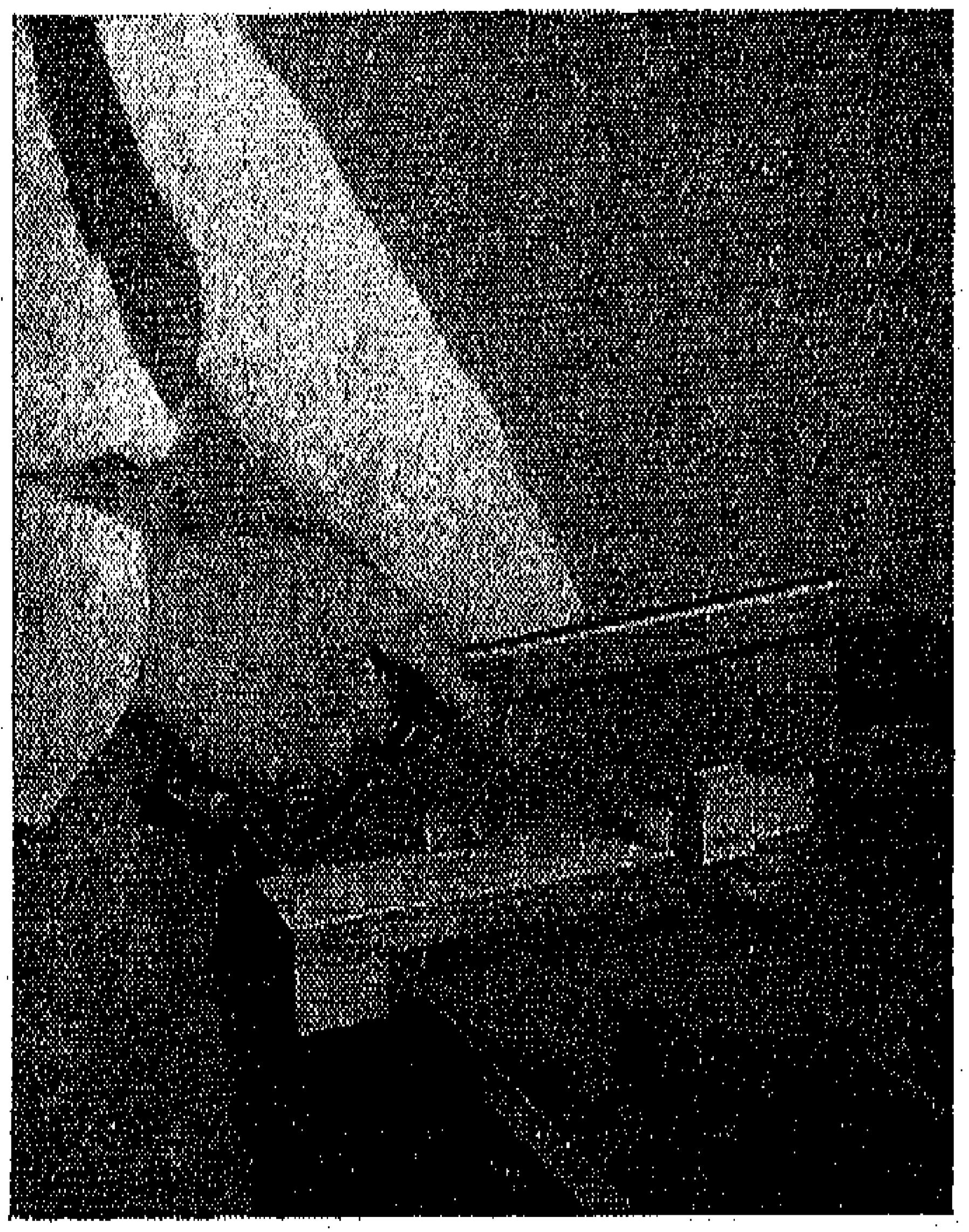


Fig. 10

Mitre-block.—To use the mitre-block, first place a thin piece of wood on the base to prevent the saw damaging the surface when finishing the cut. Next place the work against the block and hold it firmly in position with the left hand. Gently saw down into the selected slot, taking care that the saw runs freely. Do not force the saw against the sides of the slots or they will be enlarged, resulting in inaccurate work. Figure 12 shows a mitre-block in use.

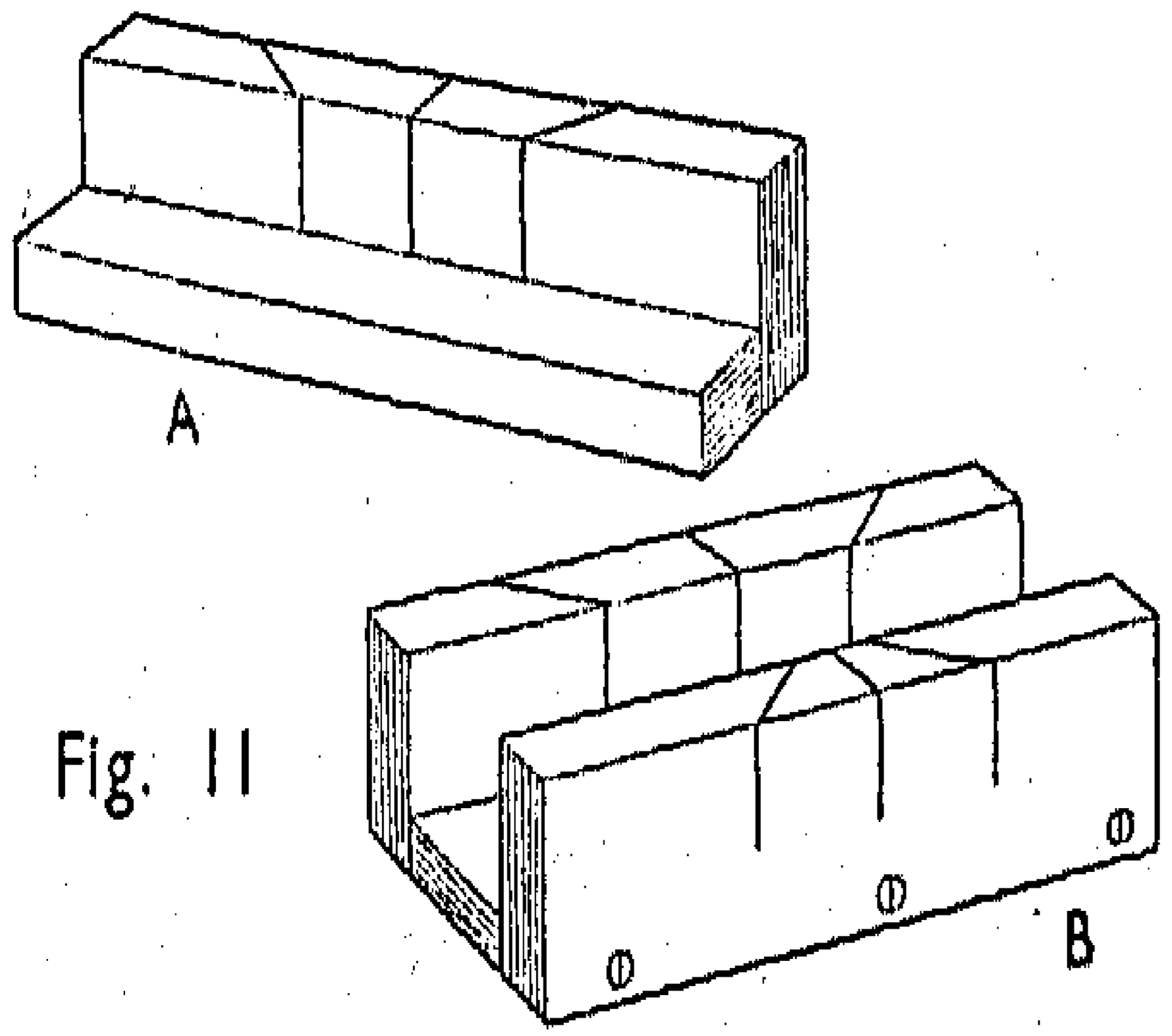


Fig. 11

The Mitre-box, as its name suggests, is box-shaped and is deeper than the mitre-block. It is used principally with the panel-saw for cutting mitres, etc., on deeper and larger mouldings than can be sawn on the block. Sawing is accomplished in the same way as with the mitre-block, and the same precautions should be taken to prevent forcing the saw and damaging the slots.

The craftsman would be well advised to drill two holes through the blade of his tenon-saw to enable a strip of wood to be screwed to the side of the blade, as

shown in Fig. 13. This arrangement acts as a depth gauge, which will be found very useful when cutting shallow slots which have to be of uniform depth, such as grooves for shelves or partitions in drawers.

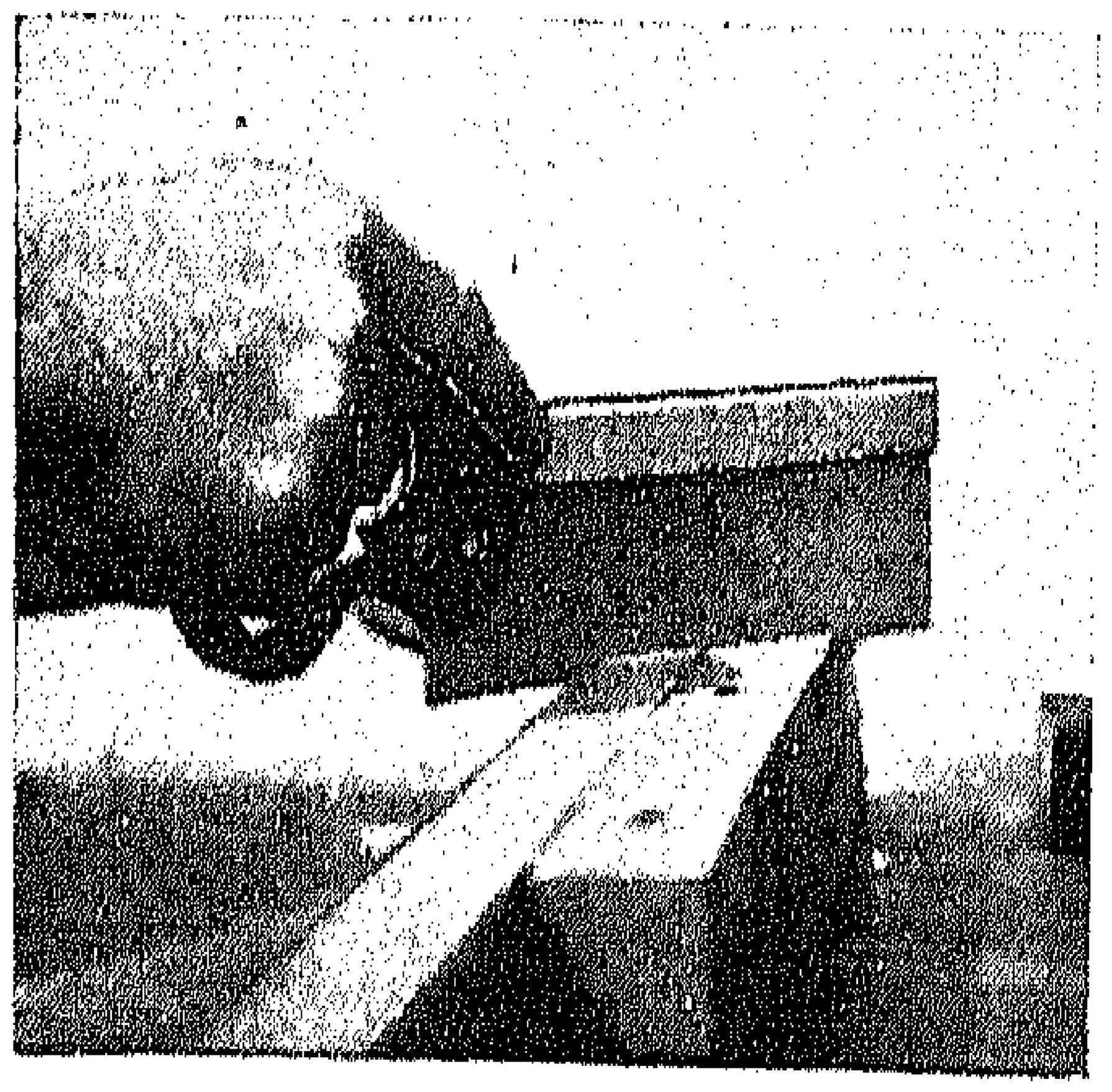


Fig. 12

A Dovetail-saw is used for sawing small stuff. It is smaller than the tenon-saw, has an open handle, and usually has about 12 teeth to the inch. The tool is used in a similar way to the tenon-saw.

The Pad-saw is a very handy little tool for cutting curves either on the outside or inside of a piece of work. Fig. 14 shows such a tool. The blade is thin, narrow and tapered and is adjustable. It is held in the handle by means of two set-screws which allow the length of the blade to be adjusted at will. New blades can be purchased separately should you have the misfortune to break one. Fig. 15 shows the correct way to use a pad-saw. It will be noted that both hands are used for gripping the tool. The index finger of the right hand is extended to control the tool, as in using the hand-saw.

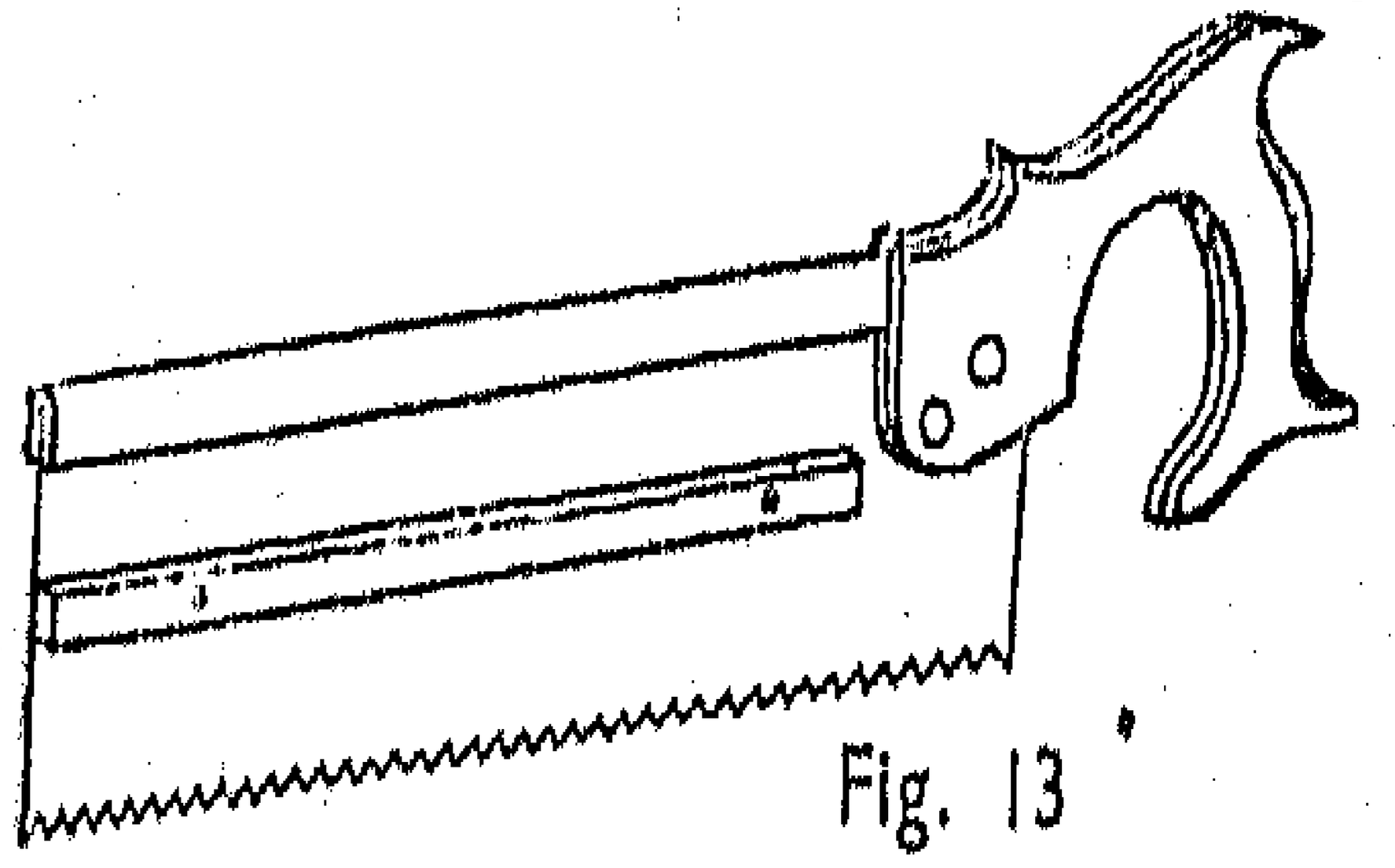
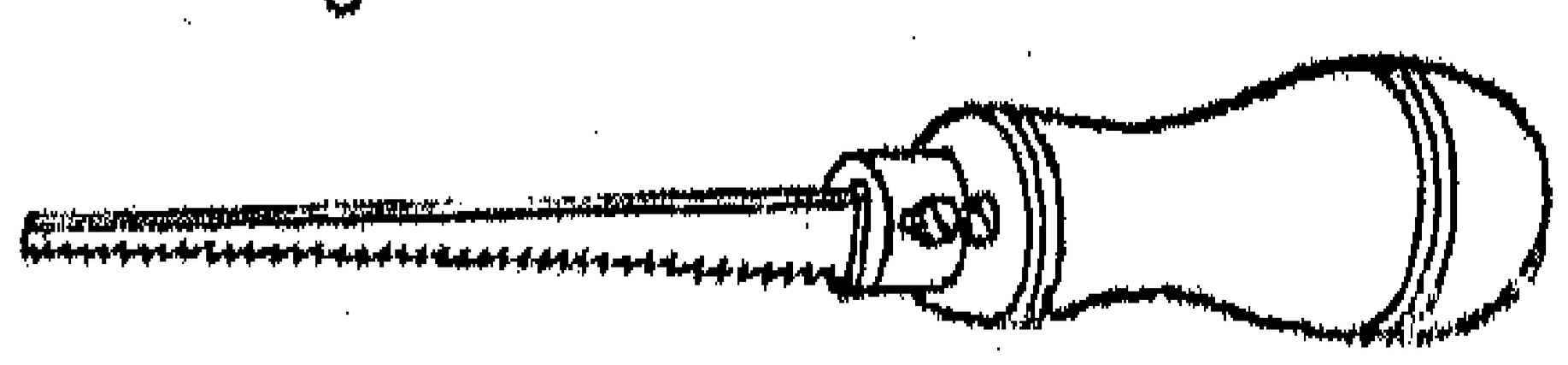


Fig. 13

Owing to the fragile nature of the blade great care must be exercised to prevent buckling. This can be obviated to a great extent by exposing only sufficient length of blade, as may be necessary, and sawing with slow even strokes.

Bow-saw.—Another type of saw for cutting curves in wood is illustrated by Fig. 16, which shows a bow-saw. This type of saw is really a large fretsaw for working comparatively thick material. The blade is parallel, thin and narrow. It is fixed between the top and bottom arms of the frame, and is kept in tension by a strong, twisted string. When fitting the blade take care to insert it correctly, that is, in the opposite direction to that of a fretsaw, as the cutting strokes are made away from the operator.

Fig. 14



To use the saw, grip the handle with both hands as shown in Fig. 17, and work the saw back and forth with steady even strokes. Avoid twisting the blade suddenly, otherwise you may break it, and always keep the blade at right angles to the work.

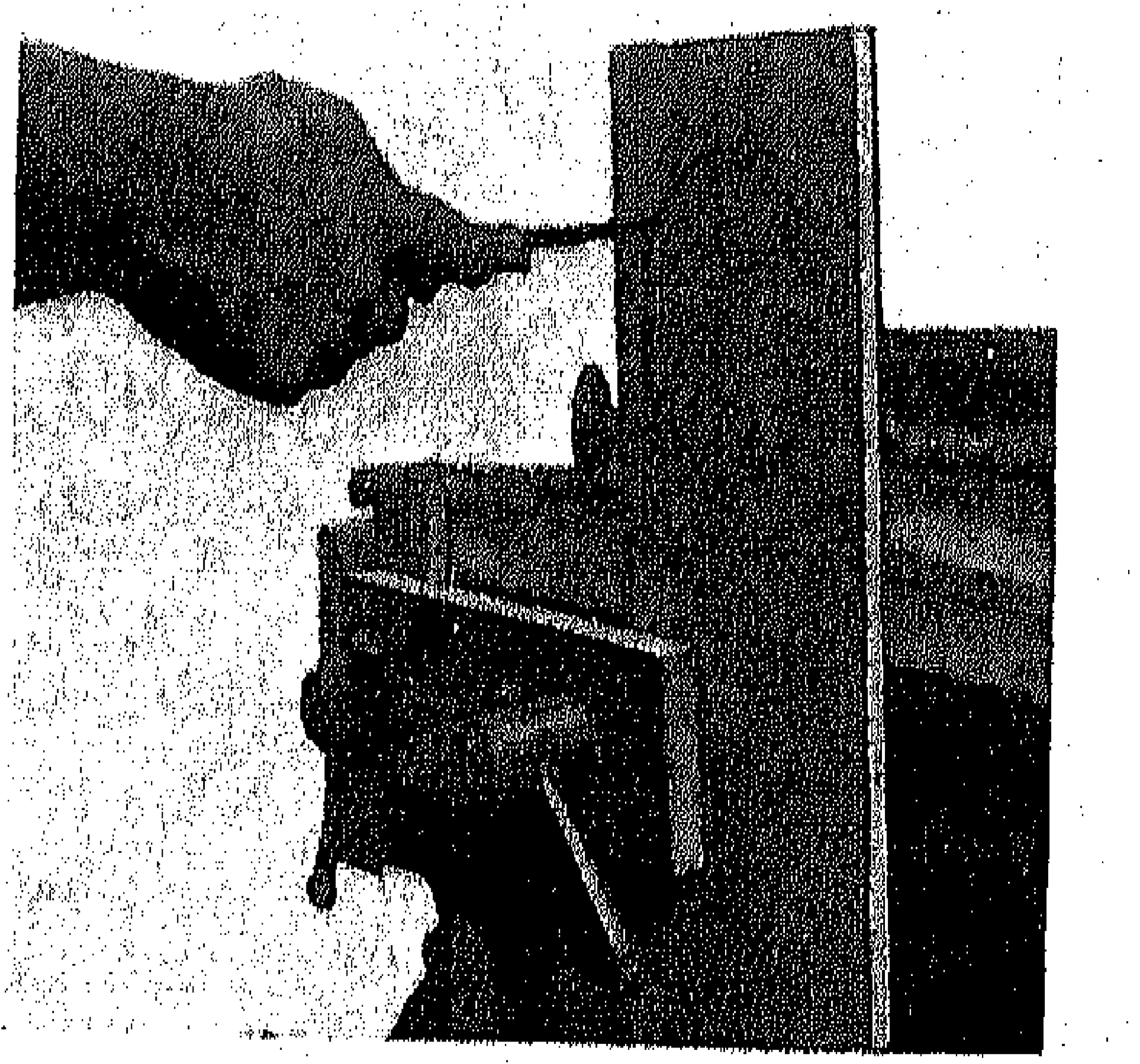


Fig. 15

For cutting internal curves a small

hole must first be made in the work. One end of the blade is then unfastened and threaded through the hole in the same manner as a fretsaw.

When not in use it is a good plan to relieve the tension on the blade by untwisting the string.

As it is not a particularly pleasant job to resharpen a saw, steps should be taken to guard against the necessity. For instance, when sawing old wood note well whether any nails are in the way of the saw-cut, as there is nothing like a nail to take the edge off the teeth. Avoid placing the saw teeth downwards on the bench; lean it on something at the back, teeth upwards; or, better still, hang it up when not in use.

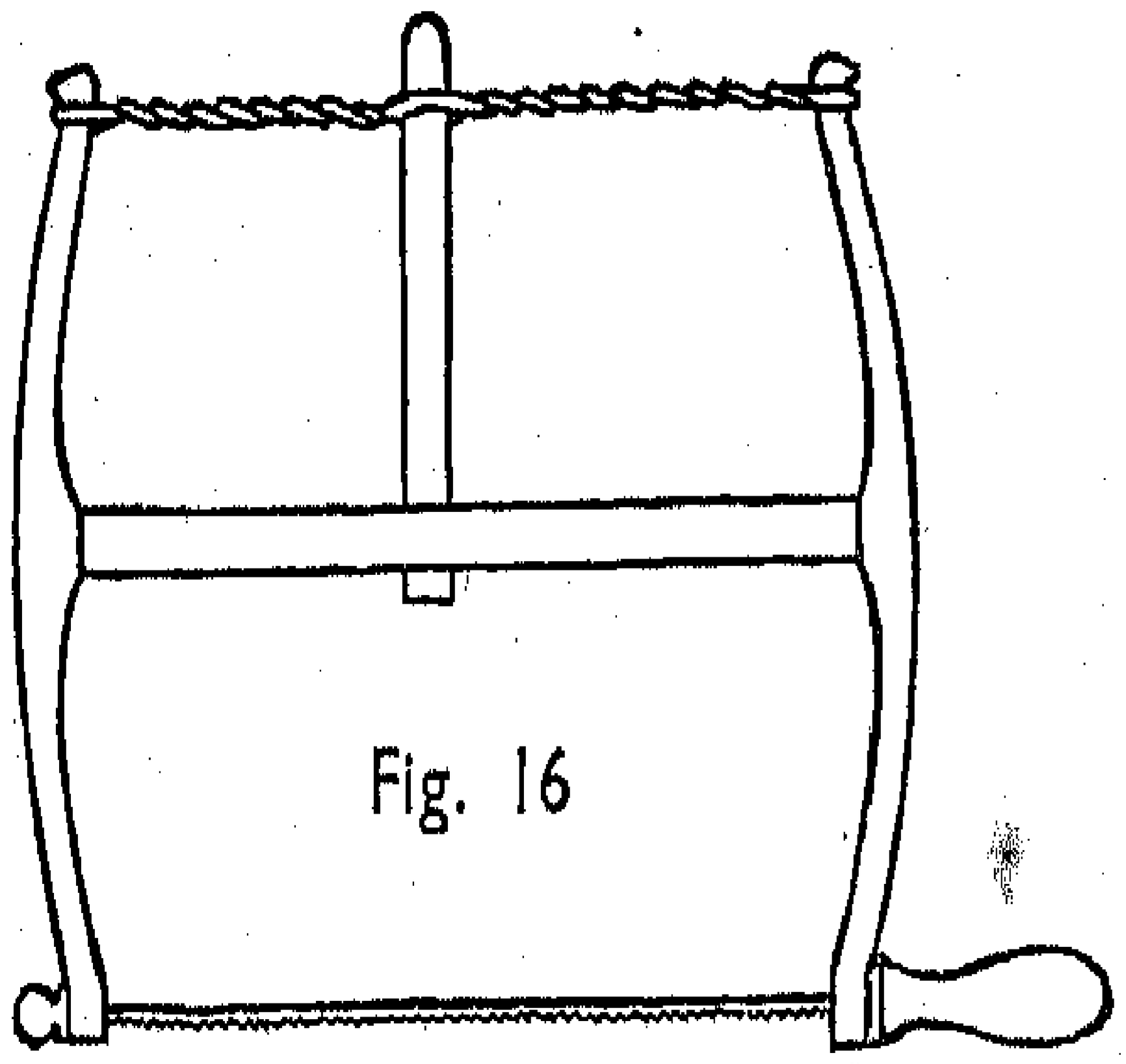


Fig. 16

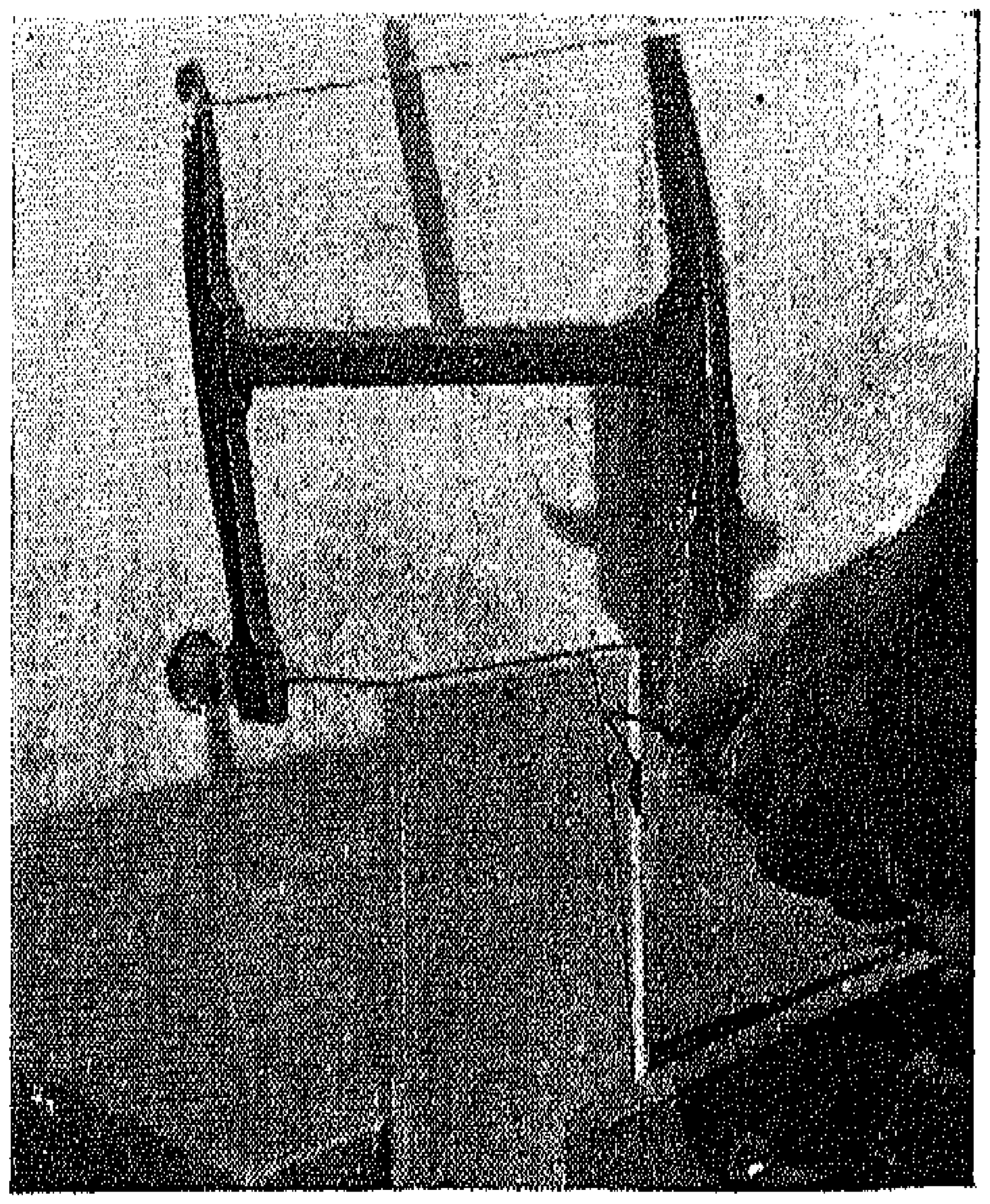


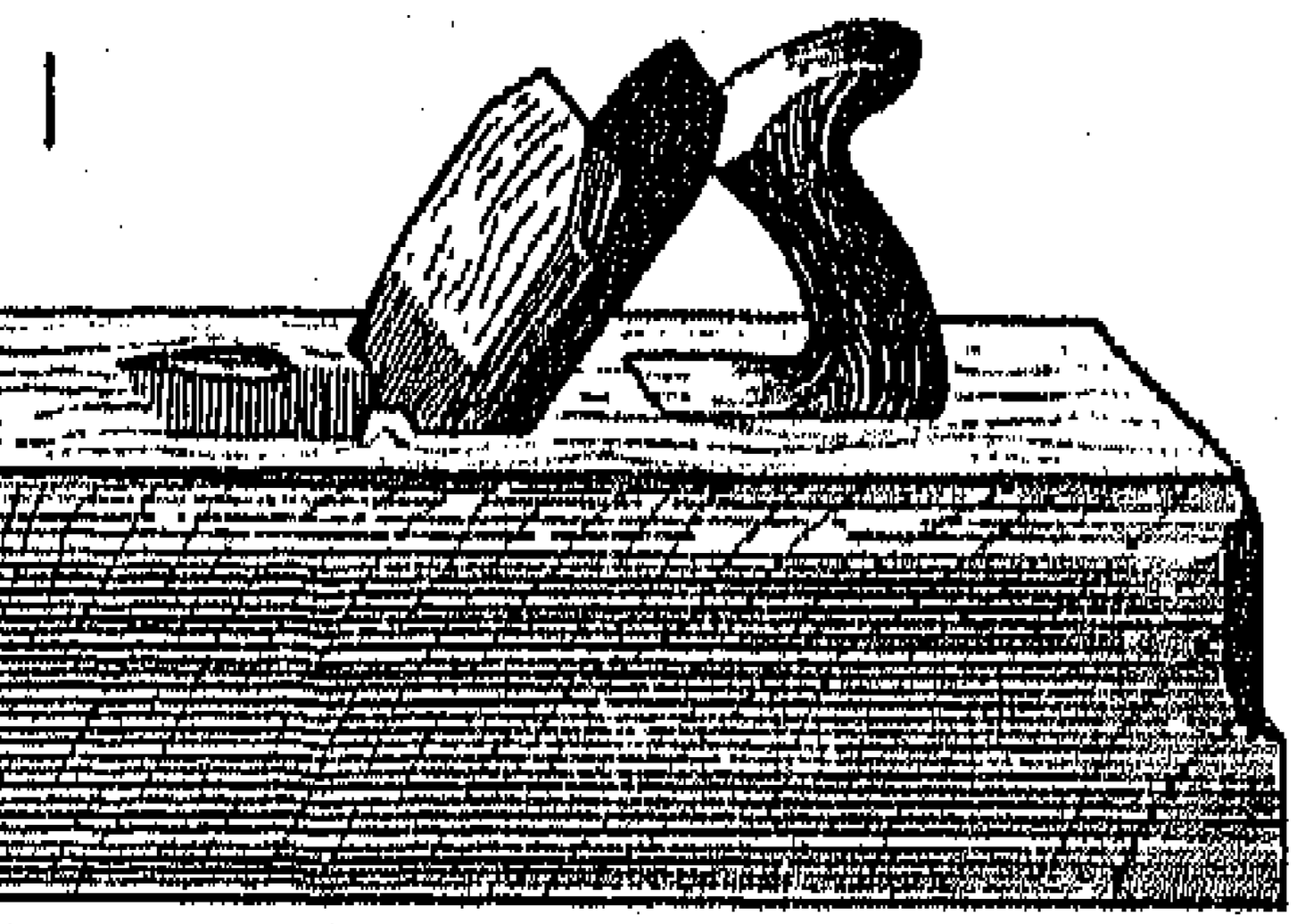
Fig. 17

PLANES AND PLANING

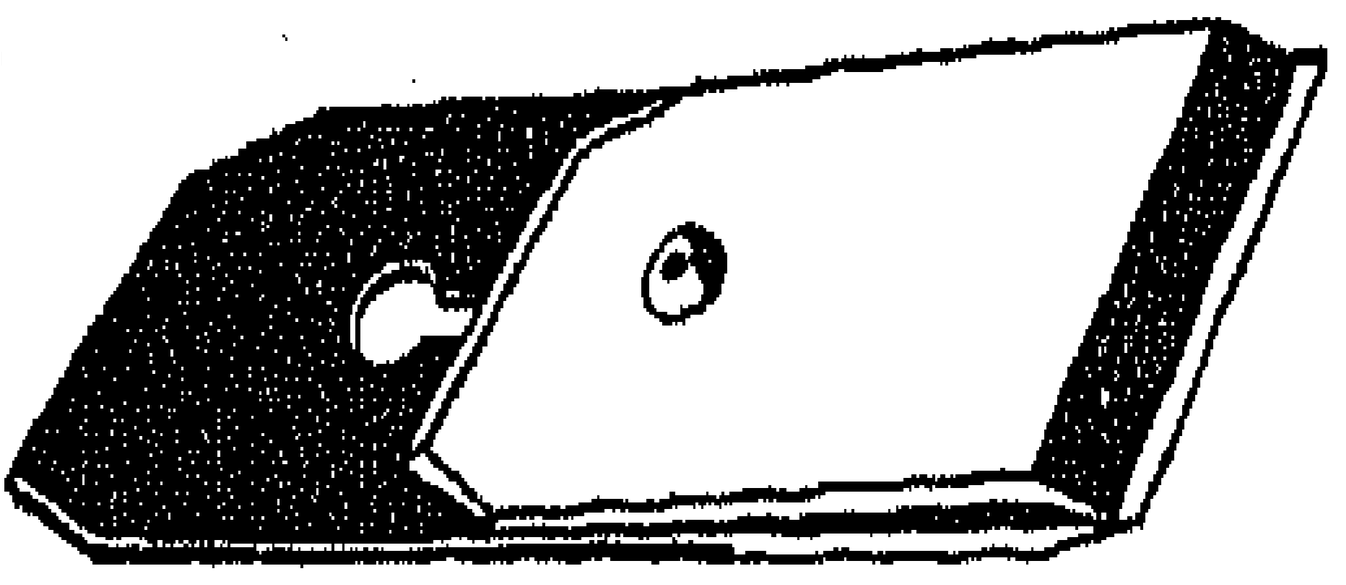
PLANING, by which is meant finishing and smoothing work truly to size, is one of the most important processes in woodworking. It is for this reason that the amateur craftsman should be able to plane up a piece of work accurately, otherwise he will be seriously handicapped in the pursuit of his hobby. As with sawing, proficiency in planing is only obtained by practice.

The principal planes used by the amateur are the jack-, trying- and smoothing-planes; but for occasional use on special work he may find it necessary to employ a rebate, router, or one or more of the special planes suitable for the work in hand.

A plane (Fig. 1) is really a guided chisel, and usually consists of a stock or body of hardwood which carries a cutting-iron held in position by a wedge, and in the case of a jack- and a try-plane a suitable handle for propelling it along the work. The bottom surface, or sole as it is termed, is perfectly flat and has a slot through which the cutting-edge projects. The thickness of the shaving is determined by the amount of cutting-edge exposed below the face of the sole.

Fig. 1


The irons employed in the jack-, trying- and smoothing-plane consist of two components, namely, the cutting-iron proper and a supporting iron, termed a back iron.' The purpose of the back iron is to support the steel cutter and to break the shavings when being cut. (An illustration of a plane-iron appears in Fig. 2.)

Fig. 2


If the rough sawn surface of a piece of wood has to be planed it is first rough-planed with a jack-plane to remove most of the waste material. This operation is followed by a trying-plane to obtain a straight and true surface, and lastly a smoothing-plane to give the material a smooth even finish.

The Jack-plane is usually about 16 in. long, fitted with a 2$\frac{1}{8}$ in. wide cutting-iron. The edge of the cutter is slightly convex or rounded (as shown at A in Fig. 3) to enable it to work freely and quickly. It produces a series of shallow grooves in the material (as illustrated in Fig. 4) which are afterwards removed by the trying-plane.

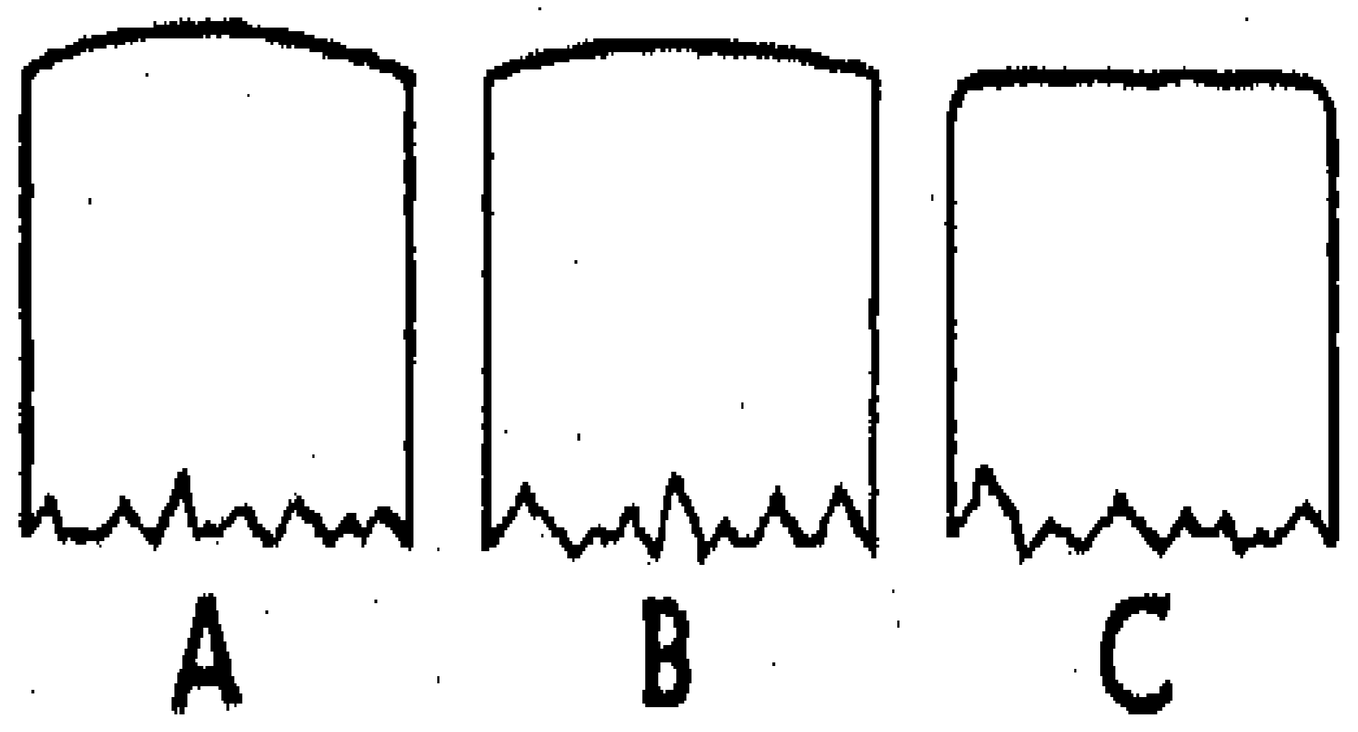
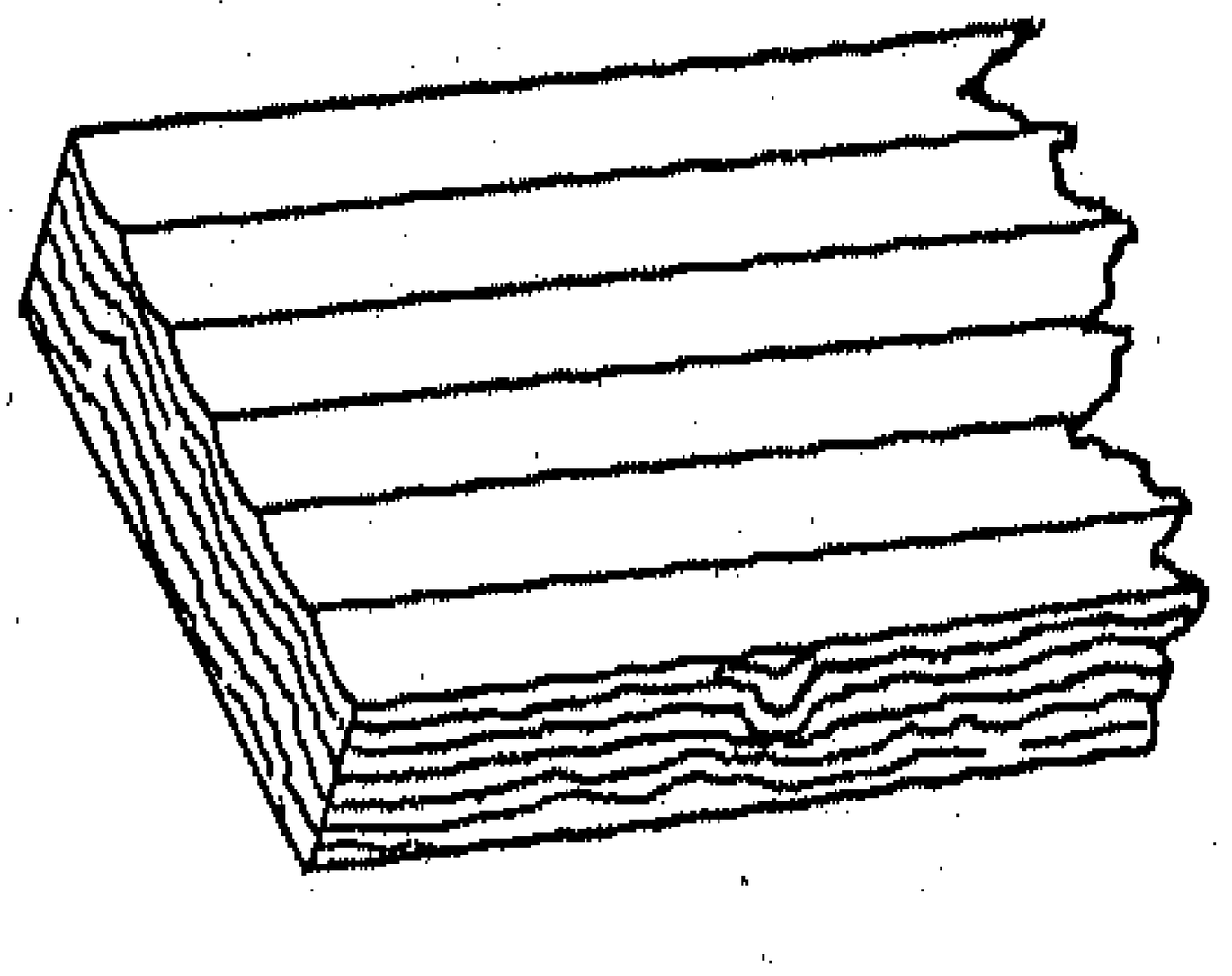


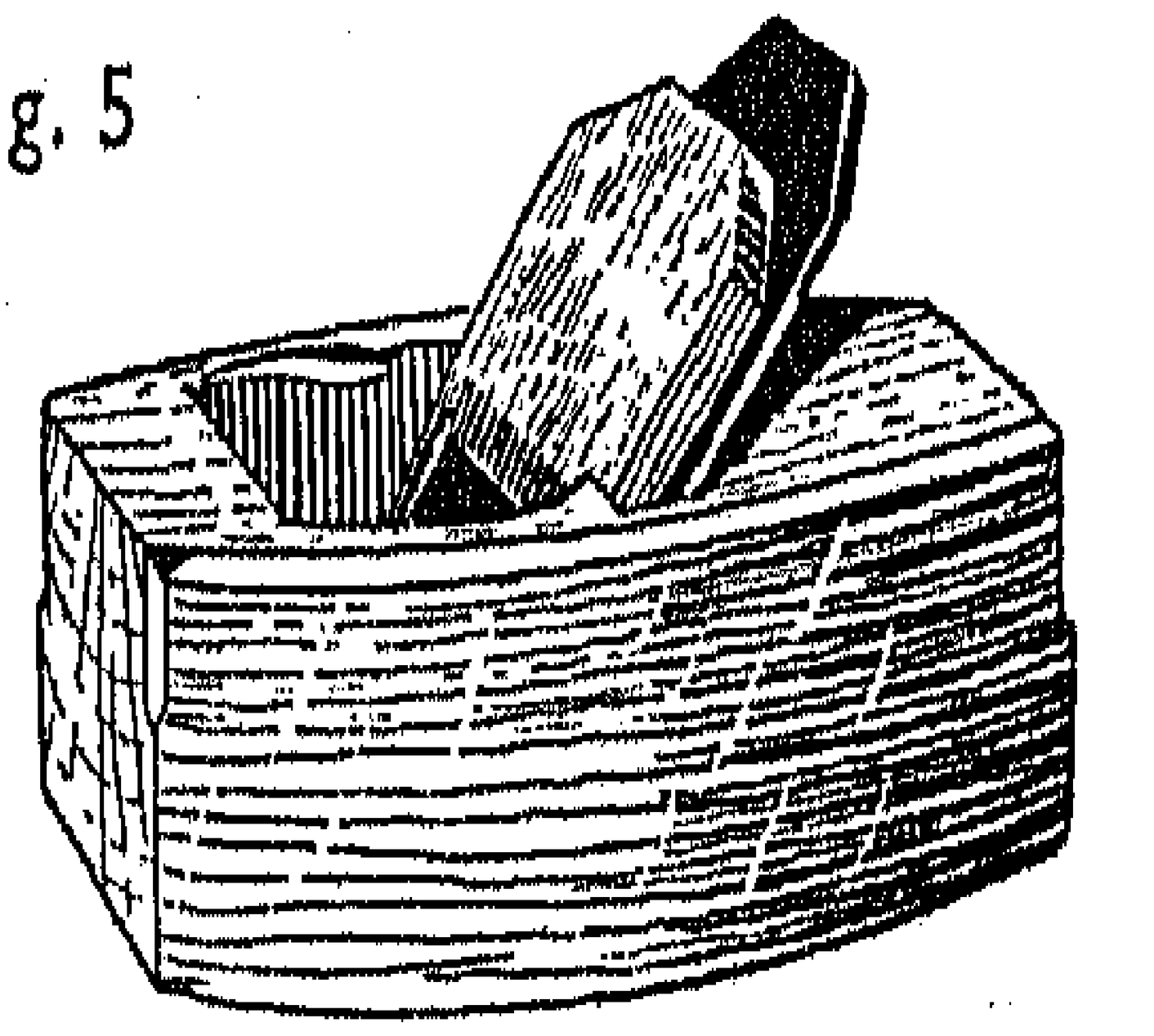
Fig. 3

Fig. 4


The back iron is usually set back about $\frac{3}{32}$ in. from the cutting-edge.

The Trying-plane is a similar tool to the jack-plane, the main difference being that it is longer, usually about 22 in., which allows all the uneven or lumpy parts left from the jack-plane to be smoothed down. The cutter is about $\frac{3}{8}$ in. wider than the roughing tool and is ground slightly rounded (as at B in Fig. 3) but not so much as that of the jack-plane, while the back iron is set closer to the cutting-edge, usually about $\frac{1}{16}$ in.

A Smoothing-plane (an illustration of which appears in Fig. 5) is generally 7 to 8 in. in length and fitted with a 2$\frac{1}{4}$ in. cutter. The cutting-edge is practically straight (C, Fig. 3), except at the ends, which are rounded off a trifle to prevent them scoring the work.

Fig. 5


The back iron is set nearly level with the cutting-edge, the distance being regulated according to the degree of finish required.

For the purpose of explaining the process involved in planing, it is assumed that a piece of rough sawn timber is to be finished, 3 ft. in length, 4 in. wide, and 1$\frac{3}{4}$ in. thick for a certain piece of work.

Before beginning operations always examine the material to see that it is entirely free from grit or other foreign matter likely to dull the cutting-edge of the iron. Place the better side of the wood upwards flat on the bench-top, with one end against the bench-stop, taking care to see that the grain of the timber runs in the right direction, that is, the planing is done in the direction of the grain. Note also that the bench-stop is not allowed to project high enough to foul the plane when in use, especially if the stop is a metal one.

The first operation consists in making the work fairly smooth with a jack-plane. Grasp the handle of the tool with the right hand and place the front end of the stock flat on the work, putting the left hand on the front of the plane and keeping the thumb on the near side and the fingers on the other (as shown clearly in Fig. 6). Keep the fore end of the tool upon the work by pressing down hard on the stock. Now push the plane along the work until the cutter passes the farther end of the wood, gradually relieving the pressure as the tool approaches the end of the stroke. Draw the plane back to its original position, still keeping the left hand on the front, but, of course, without pressure, lifting the back of the tool a trifle to keep the cutter from touching the work. Continue the operation until the whole of the surface is planed. If the shaving is very thick and it takes a great deal of force to propel the tool it usually shows that the cutter is set too deeply, in which case the obvious remedy is to re-set the cutter so that the cutting-edge does not project so far below the sole. If, on the other hand, the shaving is too fine, one or two light taps on the top of the iron will generally have the desired effect.

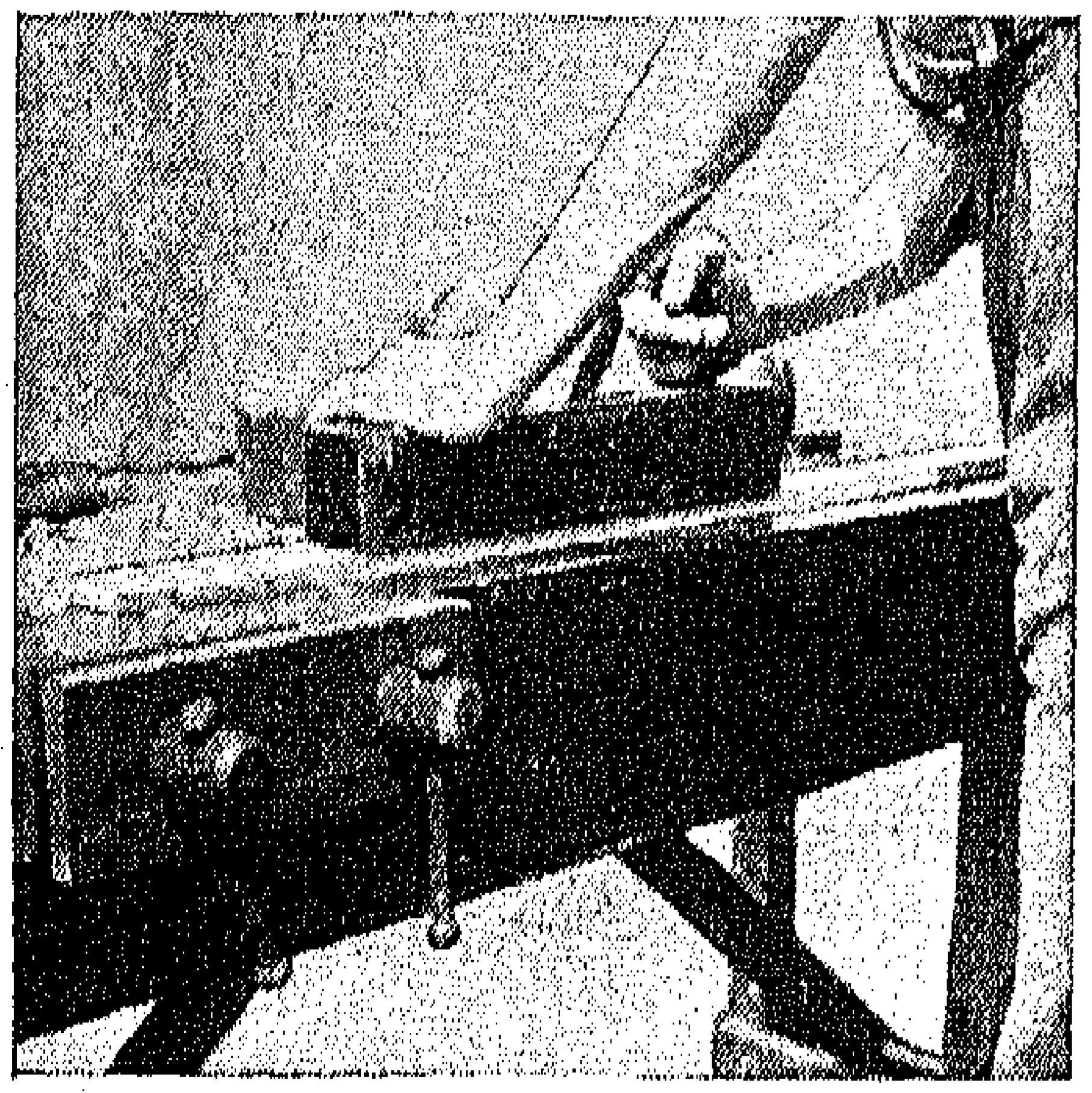
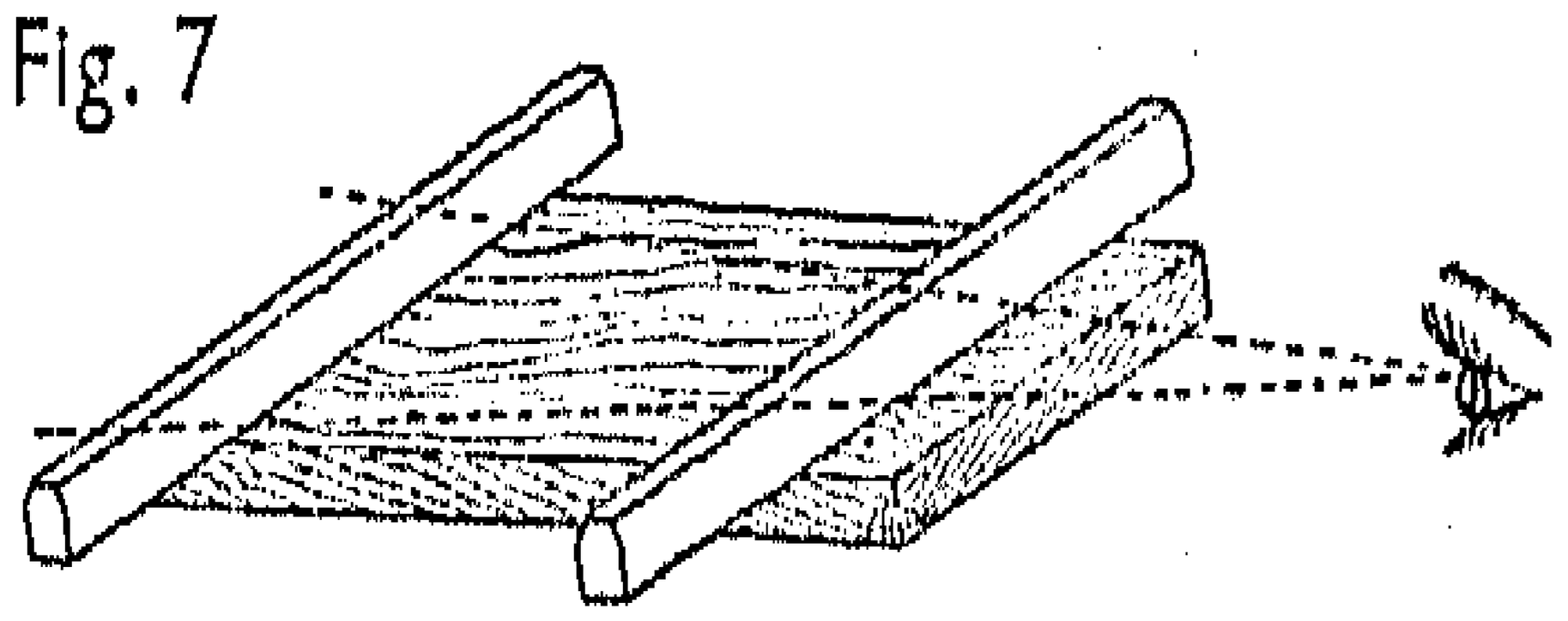


Fig. 6

Try to avoid the common error of removing too much at the farther end of the work, and also try to plane the timber perfectly flat, and not towards the sides as is often done by the uninitiated.

Fig. 7



Testing.—The work should be tested from time to time, as one of the common faults found in timber is that it has a twist. This defect may be observed by holding the work on edge, closing one eye and looking over the near top edge. If it is seen that one end of the far edge stands up more than the other it must be planed down until it is level.

A more practical method of testing, however, especially when working narrow stuff, is the use of a pair of winding strips, which are simply two narrow strips of wood a foot or so in length with their edges planed perfectly parallel. The strips are placed on edge across the work parallel to one another, at convenient distances apart. A sight is then taken over their tops as indicated in Fig. 7, when any twist which occurs is easily detected. The try-plane should be used for taking the twist out of work.

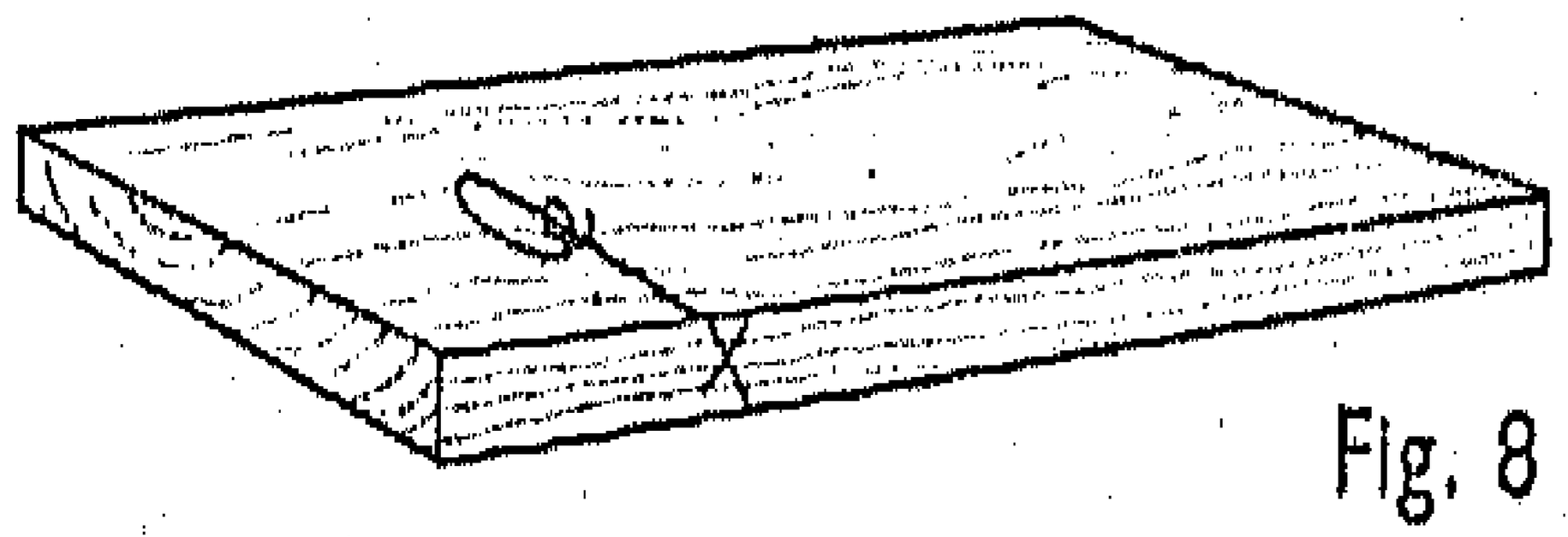


Fig. 8

After a perfectly true surface has been obtained by the try-plane—which is used in the same way as the jack—a "face mark" should be pencilled on the face and edge you are going to true up next, as shown in Fig. 8. Now place the wood in the vice, better edge uppermost, with the face towards you, as the next step is to square the edge. In planing the edge, grasp the handle of the plane with the right hand as already explained, but allow the finger-tips of the left to slide along the side of the work in the manner shown in Fig. 9. This procedure will help to steady the plane and keep it at right-angles to the already prepared face.

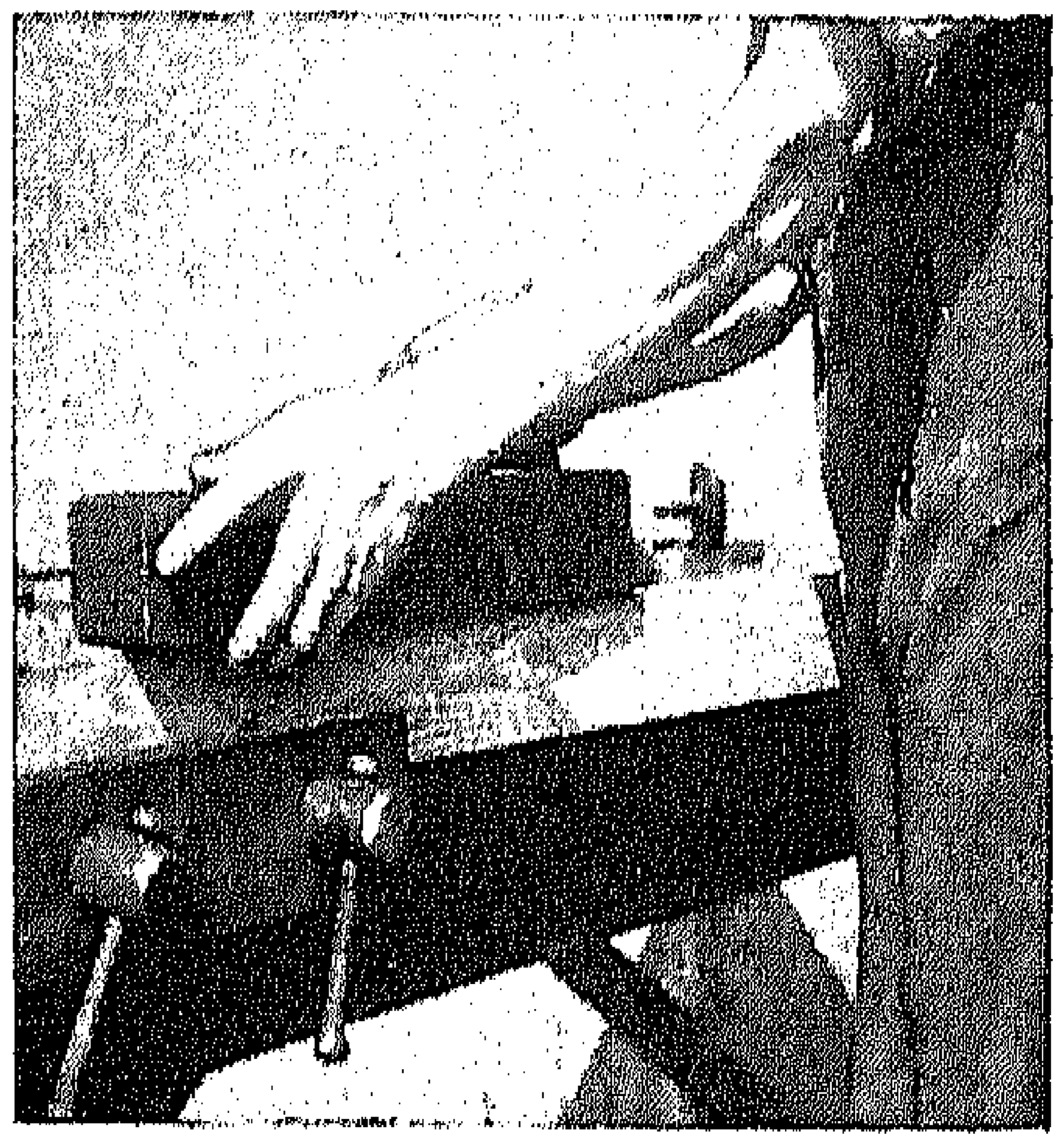


Fig. 9

As the work progresses test for accuracy with a try-square. If the work is found to be out of square, correct the fault by tilting the tool a trifle and remove the prominent parts. When the edge is finished pencil a V mark on it pointing to the face side.

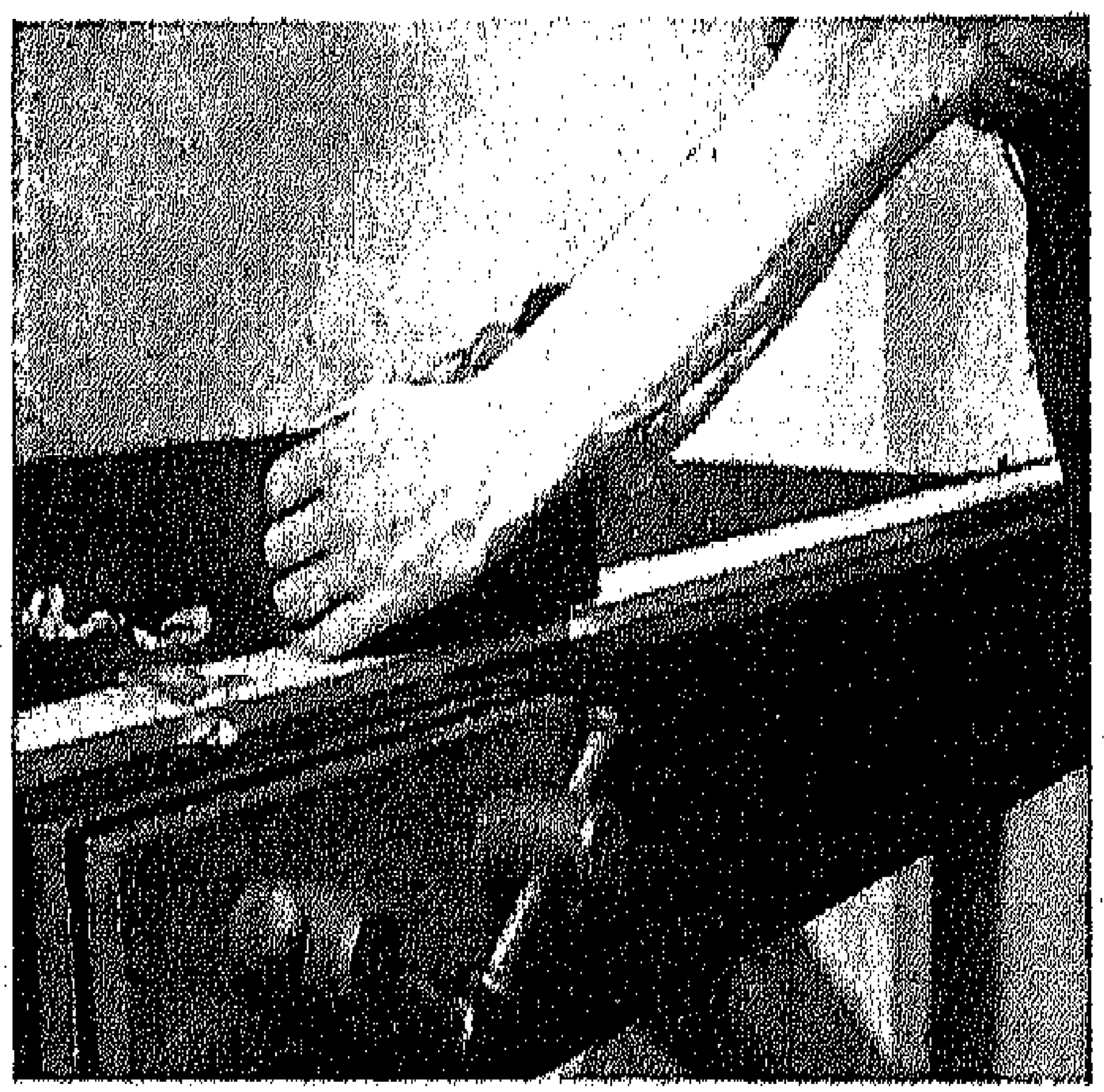
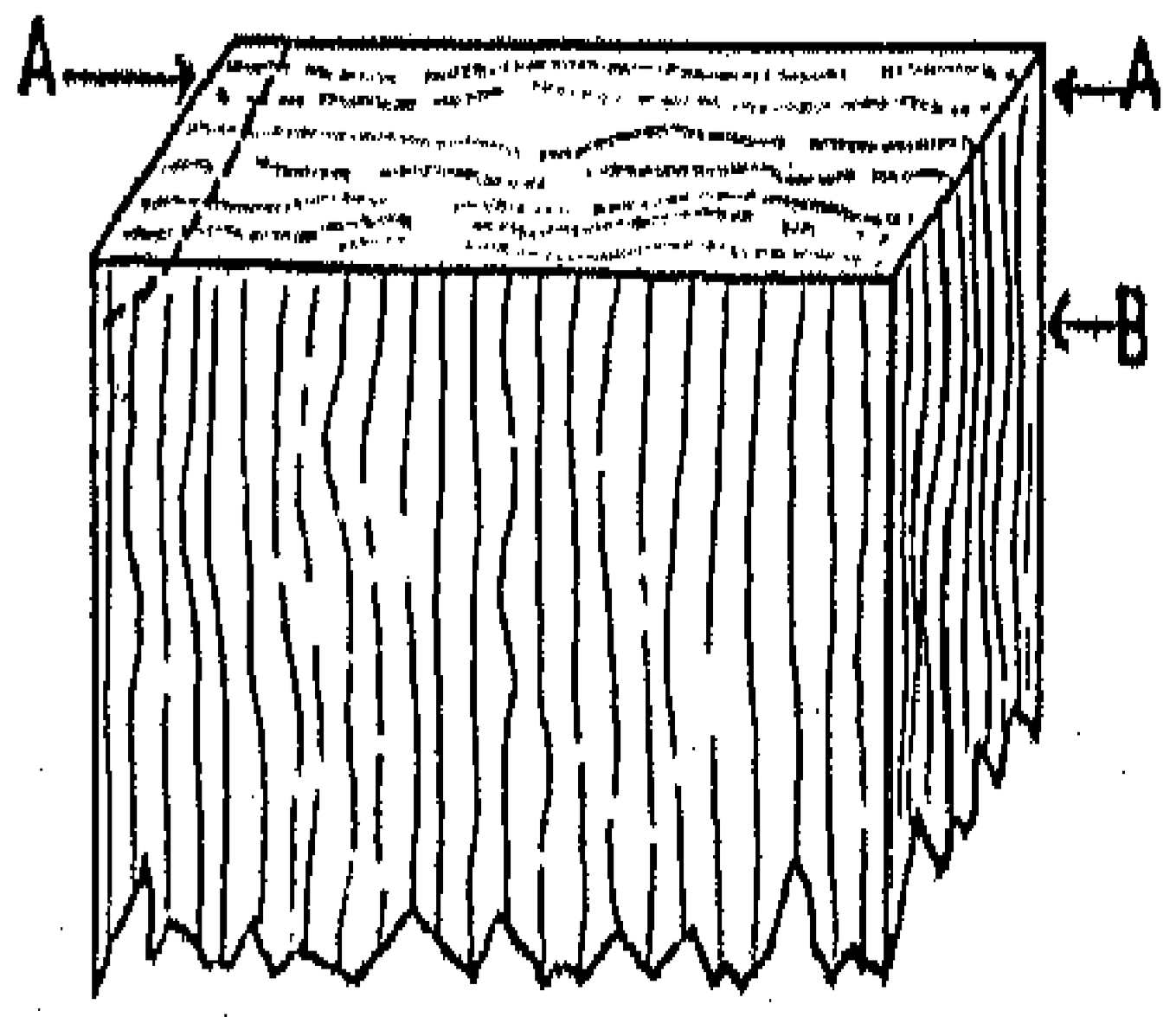


Fig. 10

Remove the work from the vice and mark out on the face side the exact width the work is to be, using a marking-gauge for the purpose. Set the marking-gauge and run the point along the face by moving the stock of the tool along the face edge. When this edge has been planed down to size and tested for squareness from the face, the work should be placed prepared face downward, to enable the remaining face to be planed. Before this can be done, however, the exact depth must be gauge-marked on the sides, by running the gauge stock along the face-edges. When this has been planed to size, the whole may be skimmed over with the smoothing-plane.

The Smoothing-plane has no handle and it is used in the manner indicated in Fig. 10. As this tool is essentially a finishing tool, the plane-iron should be very sharp, and set very "fine," that is, the cutting-edge should only project beyond the sole by the merest fraction of an inch, to produce a very fine shaving.

Fig. 11



The work is now ready for cutting to length. Measure the distance with a rule, and mark the positions on the face of the work. Square a line across the face and round the edges at each end, and carefully saw on the *outside* of these lines. Fix the work end upwards in the vice, as the final operation consists of planing the ends, which are, of course, planed on end grain. Do not attempt to plane right across the end, otherwise the opposite edge will be damaged, but work first from one edge to the centre and then from the opposite side towards the centre as indicated at A in Fig. 11 or, in cases where the preservation of the edge is immaterial, first remove the far corner—shown

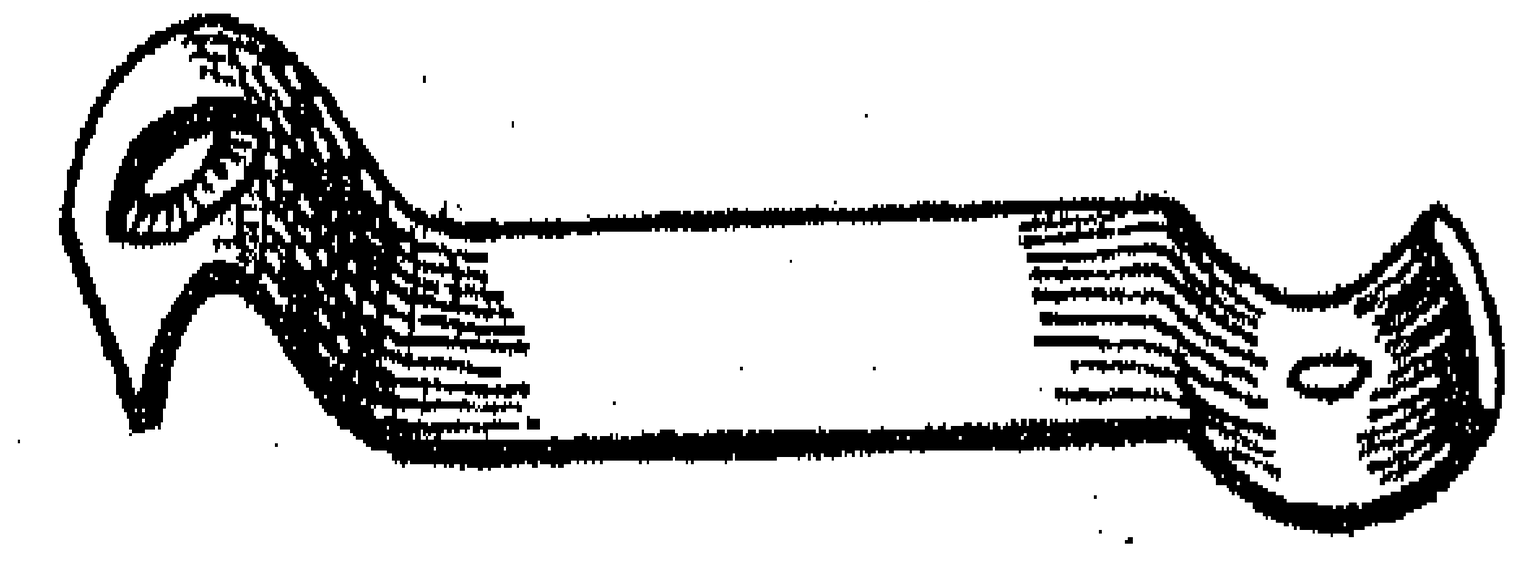


Fig. 12

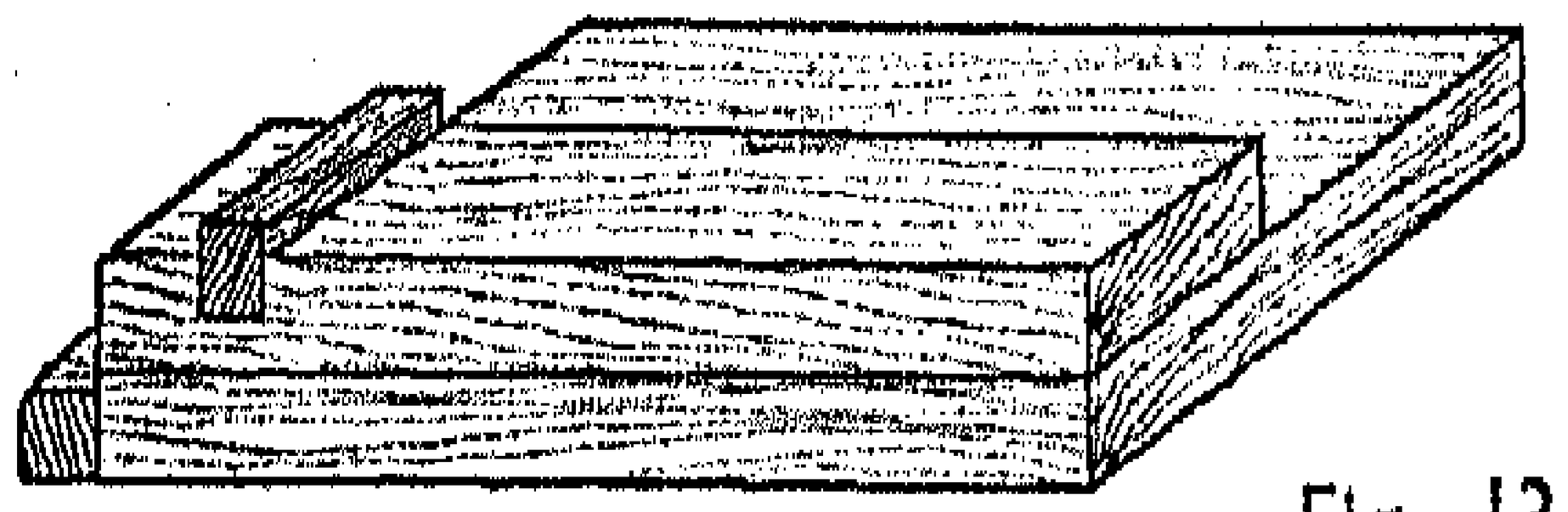


Fig. 13

by the dotted lines—with a sharp chisel, and then plane across the surface in the direction indicated by the arrow at B.

As the long edges of work are usually sharp after planing, it is a good plan to remove the "arris," as the sharp edge is called, by either running the smoothing-plane held at an angle along the edges, or by using a cornering tool (illustrated in Fig. 12). Such a tool can be obtained from almost any tool-dealer for a few pence.

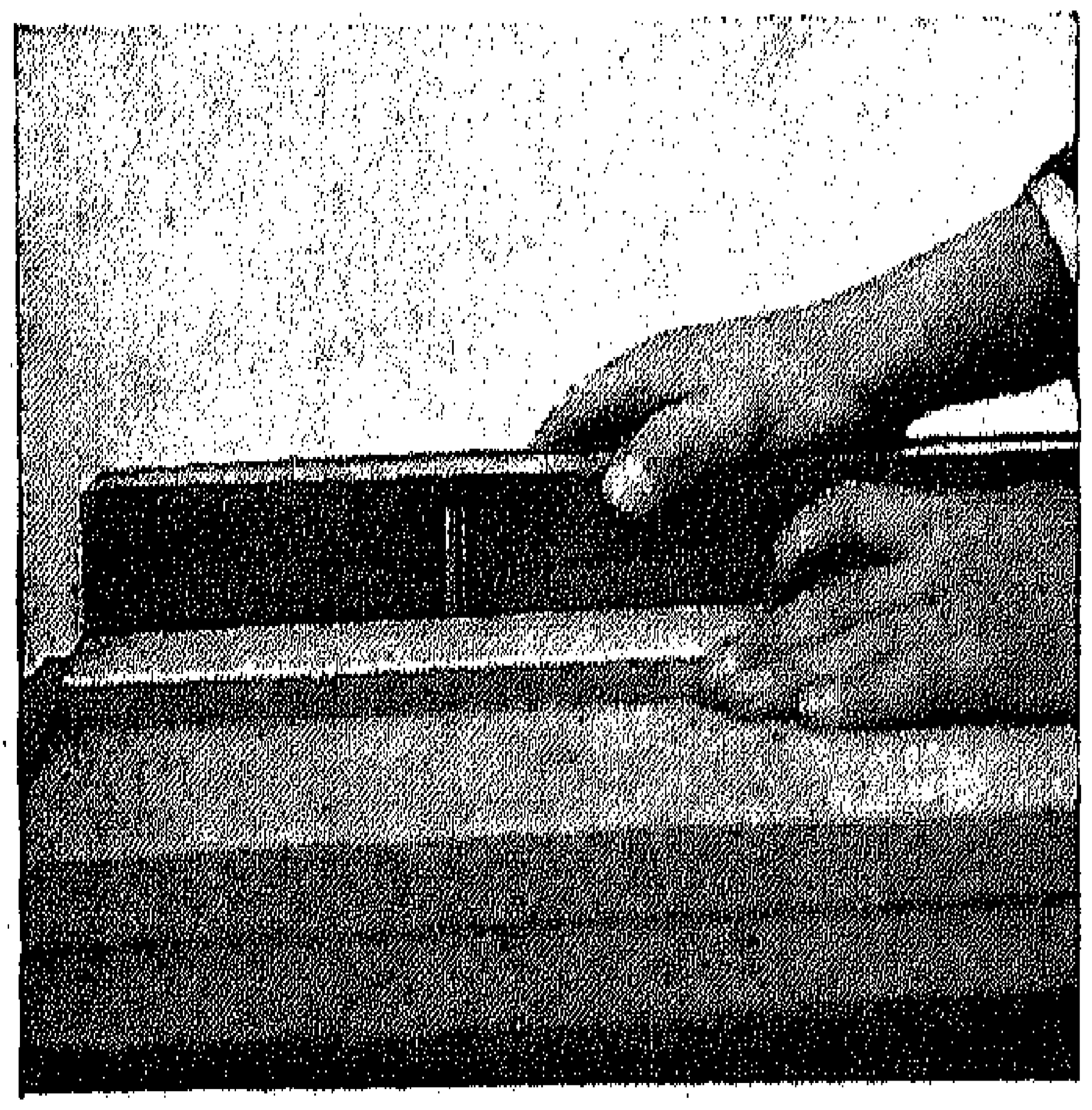


Fig. 14

The Shooting-board.—Fig. 13 shows a useful planing device. It is used for shooting or planing the edges of comparatively thin material, both with the grain and across the end grain. The board consists of an accurately planed and trued wooden base about a foot wide, an inch thick, and varying in length from 24 in. upwards. On the top of the base is a narrower prepared board running lengthwise and flush with the front of the base, and kept in position by screws driven in from the underside. A hardwood stop is grooved into the top member near the left-hand end, and as the base is liable to twist, a strengthening batten fixed on the underside at the ends is advisable.

In use the board is placed against the bench-stop, as shown in the illustration, and the work against the stop on the board. The plane is used with its side resting on the base and its cutting-edge towards the edge of the work to be prepared. The work is kept in position with the left hand while the right one propels the plane as pictured in Fig. 14.

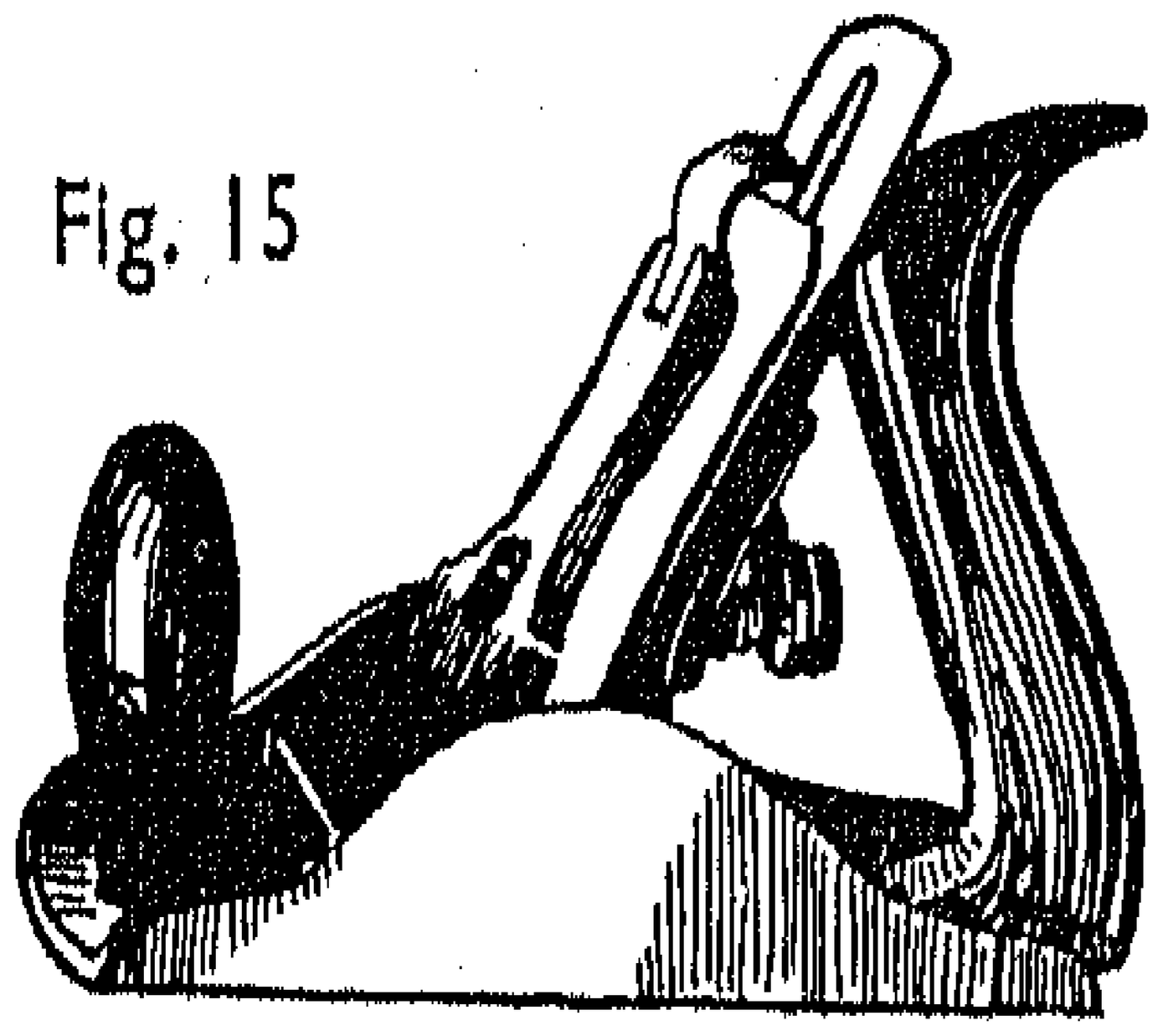


Fig. 15

When shooting the end-grain edge of a piece of work it is a good plan to insert a small piece of accurately prepared wood between the work and the stop, keeping the front edge of the piece flush with the edge to be planed. Its use ensures proper support to the corner of the work and prevents it from splitting off.

Always plane to a drawn line even when using a shooting-board. If possible, mark the line with a scribing knife. A pencil line has the disadvantage that it can get planed out easily or otherwise obliterated, but a knife-scribed line leaves a clean, clear cut to work to.

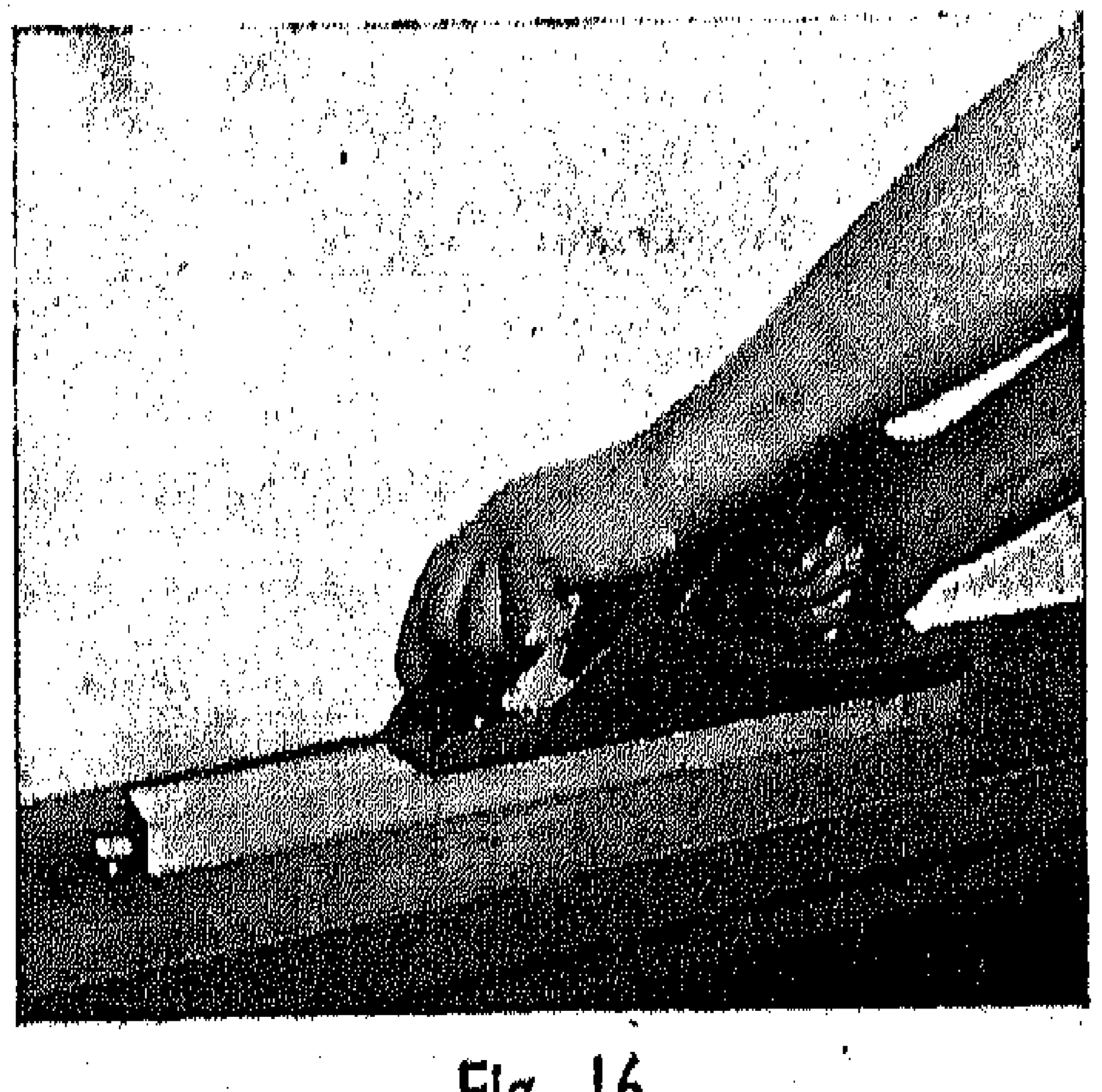


Fig. 16

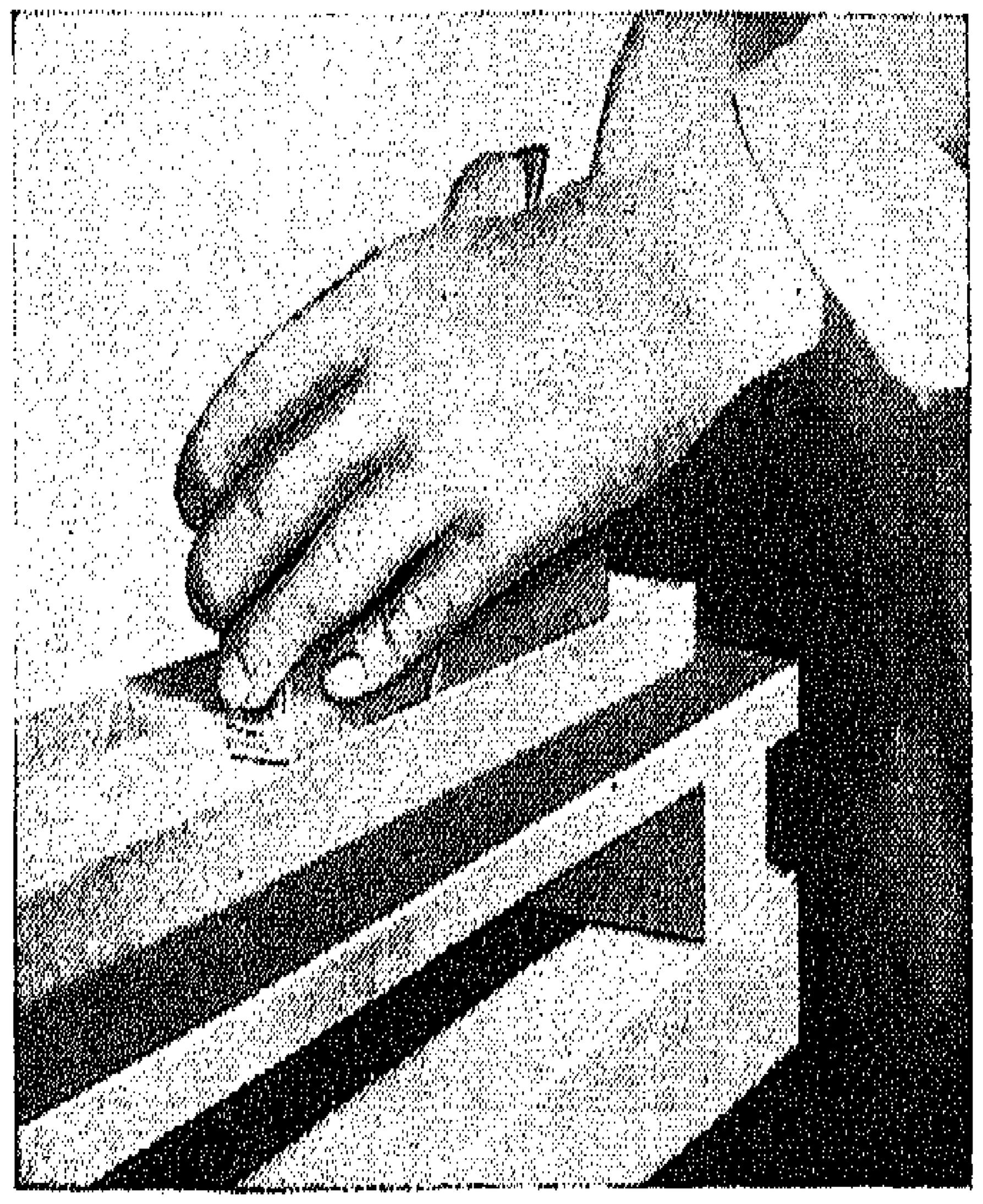


Fig. 17

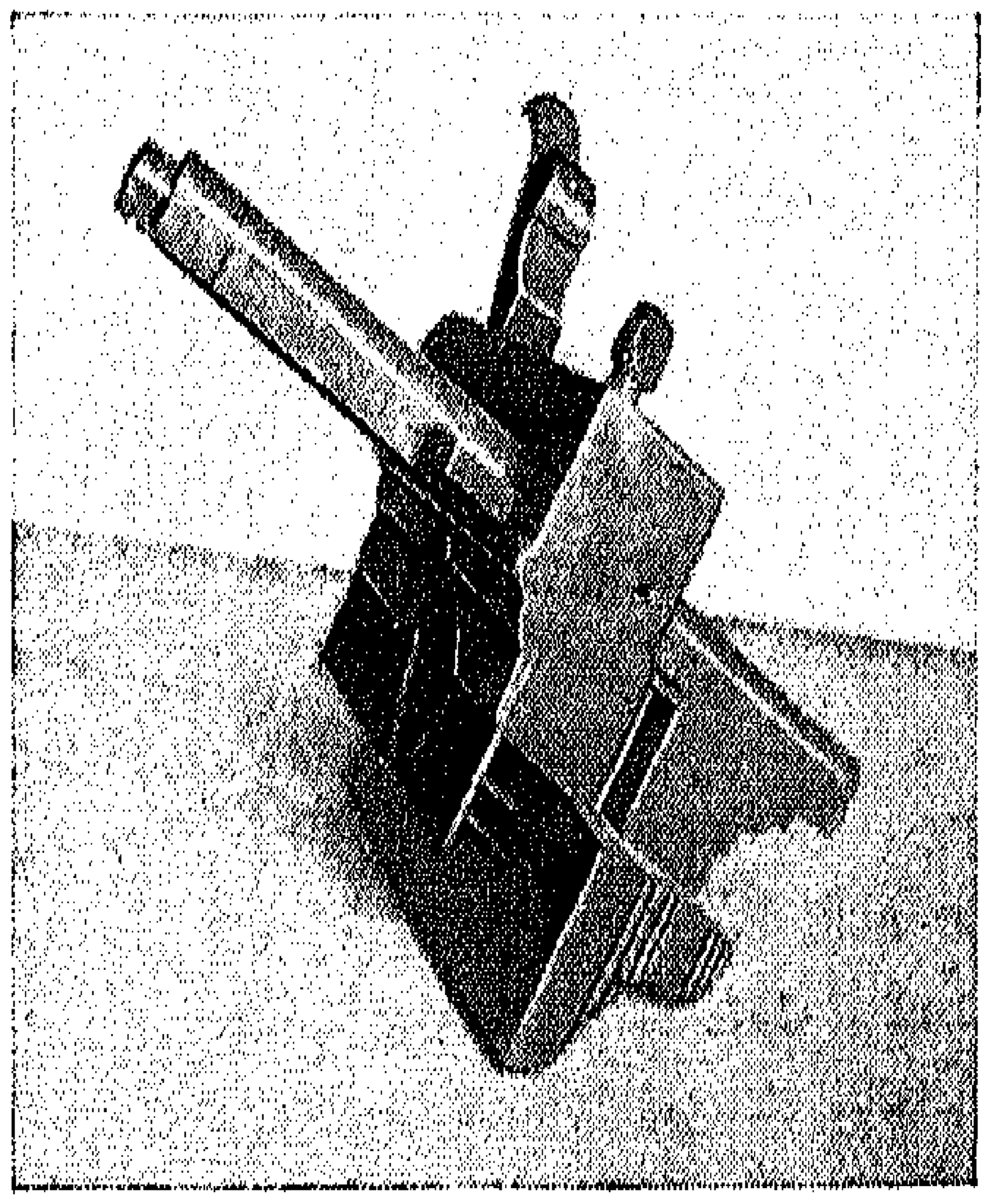


Fig. 18

Metal Planes, that is, planes having an iron stock as represented in Fig. 15, are becoming increasingly popular, especially in the smaller types. (Fig. 16 shows a metal plane in use.)

Although the jack-, trying- and smoothing-planes are the most generally used planes, there are one or two useful planes for special purposes. These include the rebating and the plough plane.

The Rebating Plane is used for finishing rebates or shoulders along the edge of a piece of wood as shown in Fig. 17. The plane is fitted with a cutting blade as wide as the body in order to cut right into the angles.

The Plough Plane (Fig. 18) is used for cutting grooves in the edges or faces of work, as indicated in Fig. 19. The tool consists of a stock and a set of cutting irons of different widths. The depth of cut is regulated by means of a thumbscrew.

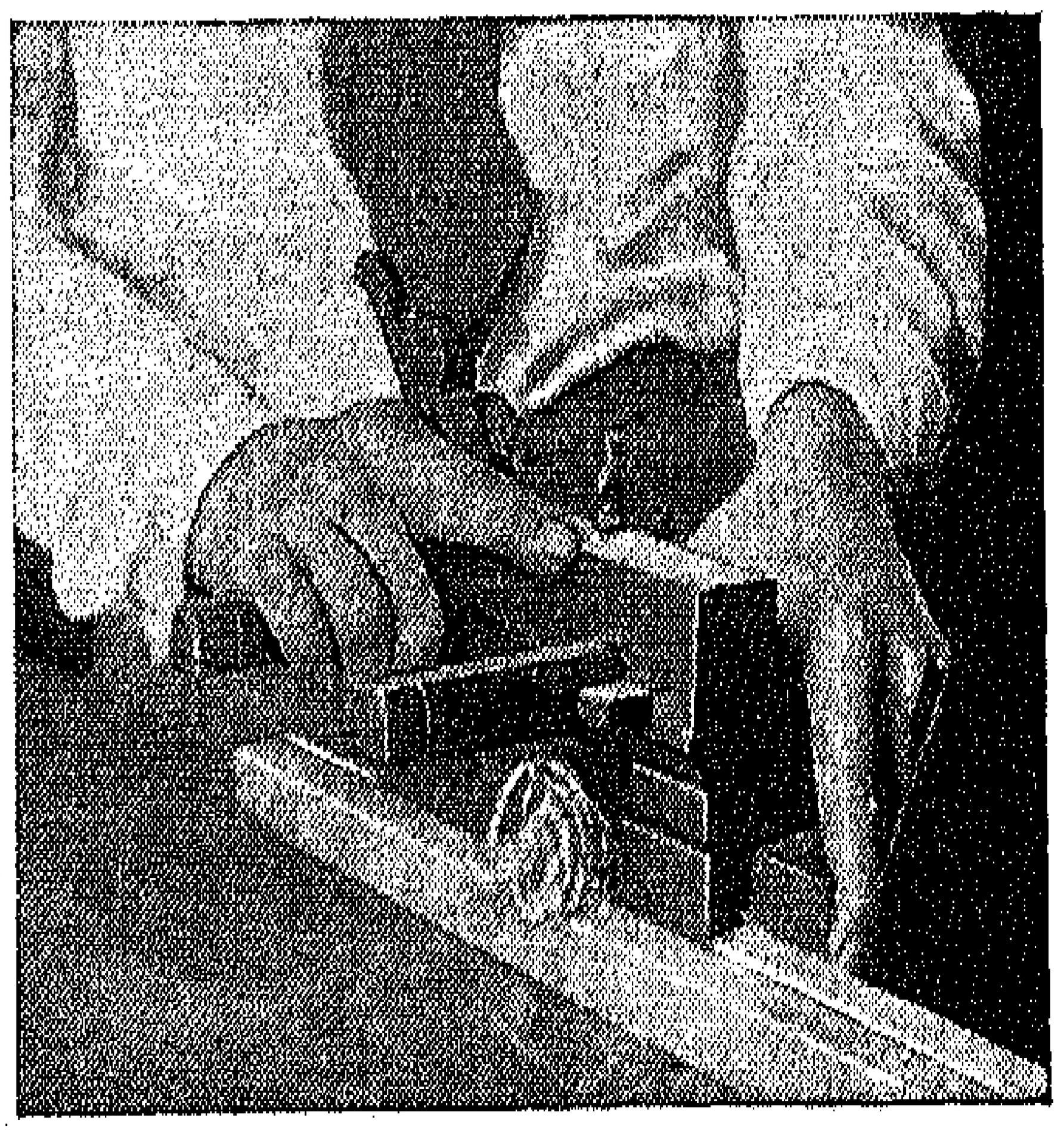


Fig. 19

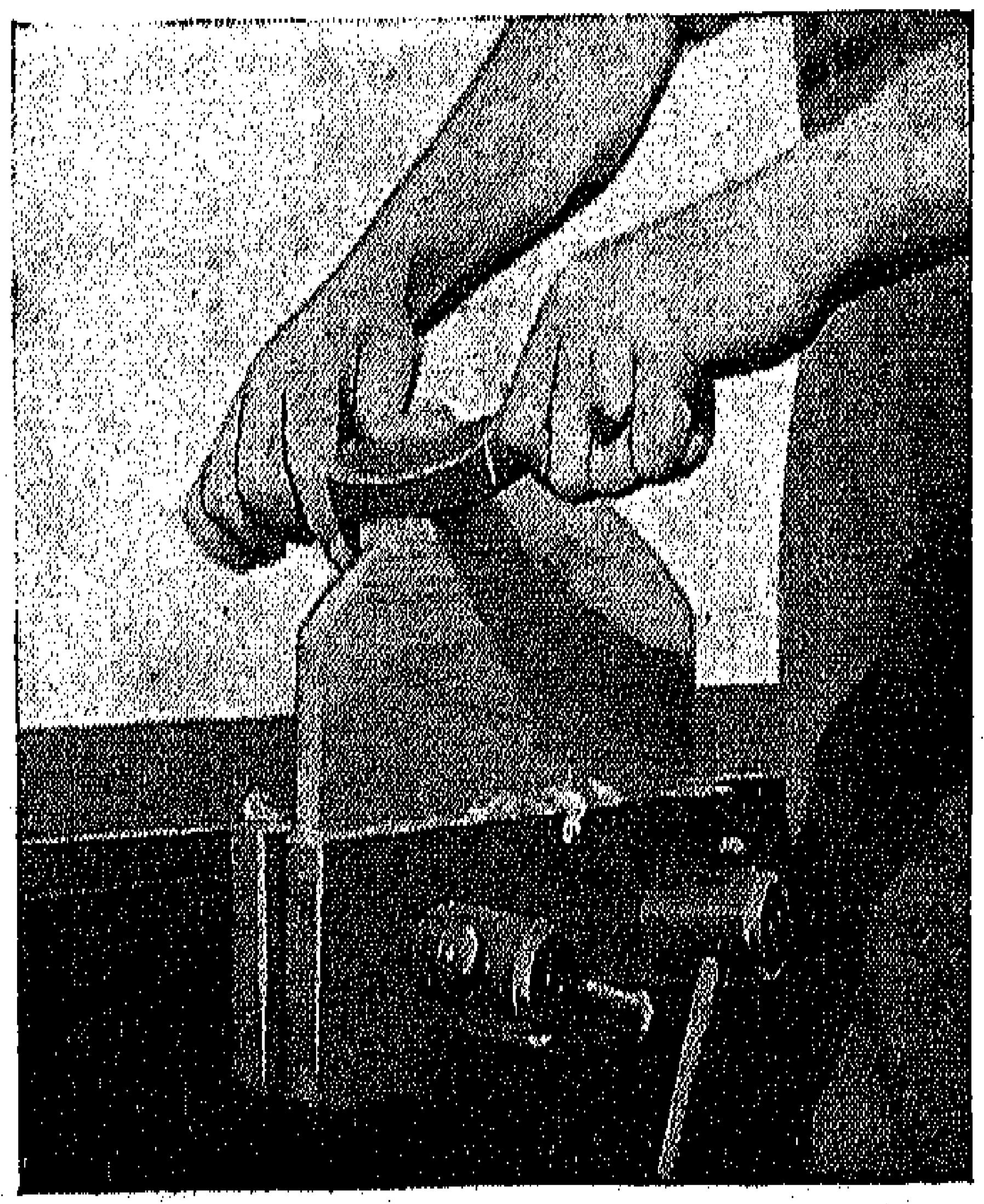


Fig. 20

A Spoke-shave is an elementary type of plane used for smoothing curved surfaces, either convex or concave. It consists of a cutting blade supported by a double-handled stock of either wood or metal. In the wooden type the blade is provided with two tapered square section projections, or pegs, which fit into corresponding holes in the stock. The blade is adjusted by tapping the tops of the pegs. (Fig. 20 shows how the tool is used.) Care must be taken to work "with the grain," and in some instances it will be found an advantage to push the tool across the surface to be finished, rather than to pull it. For ordinary work a 9-in. tool will be found useful.

MARKING OUT

Accurate marking out is the first step in the production of good work. Unless the job in hand is carefully marked at the outset, and however skilfully the subsequent operations may have been done, there is little likelihood of the finished product being anything but a failure.

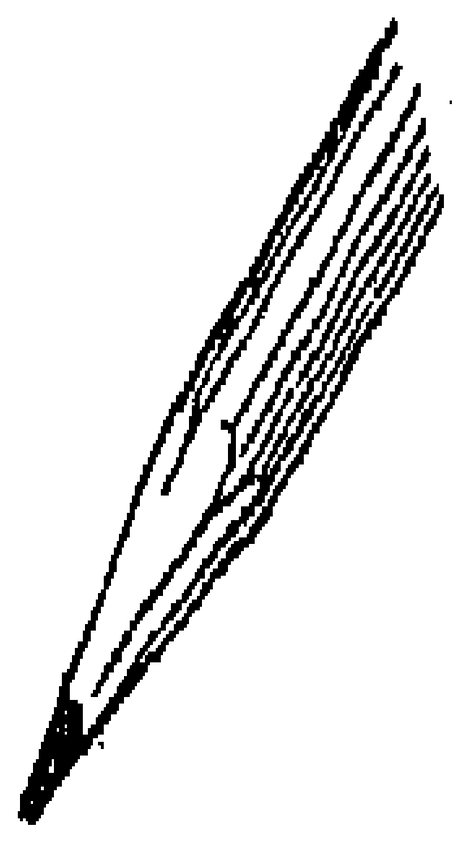


Fig. 1

The actual tools required for marking out a particular piece of work naturally vary with the kind of work, but fortunately the tools necessary for marking ordinary "everyday" work call for only a few quite inexpensive items such as a pencil, scribing-knife, rule, squares, marking-gauge, and dividers.

A Lead Pencil is generally used for marking where no high degree of accuracy is needed, but in cases where great precision is necessary—as in setting out joints and cabinet making—it is better to use either a scribing-knife or a chisel edge, as the clean cut obtained by these tools leaves a fine definite line.

The lead pencil should be sharpened to a fine chisel point as shown in Fig. 1, as it produces a clear thin line. For marking a line for rough sawing this is, of course, unnecessary.

A Rule is indispensable for measuring. The most useful and handy type for general work is perhaps the 2 ft. four-fold rule, as it can be easily carried about in the pocket.

For rough measurements it can be used flat, but for exact marking it should be held edgewise direct on the work. This is necessary because it is extremely difficult to judge and mark accurately the precise point required when the division lines of the rule are even only a small fraction of an inch above the work. You can prove this by trying it.

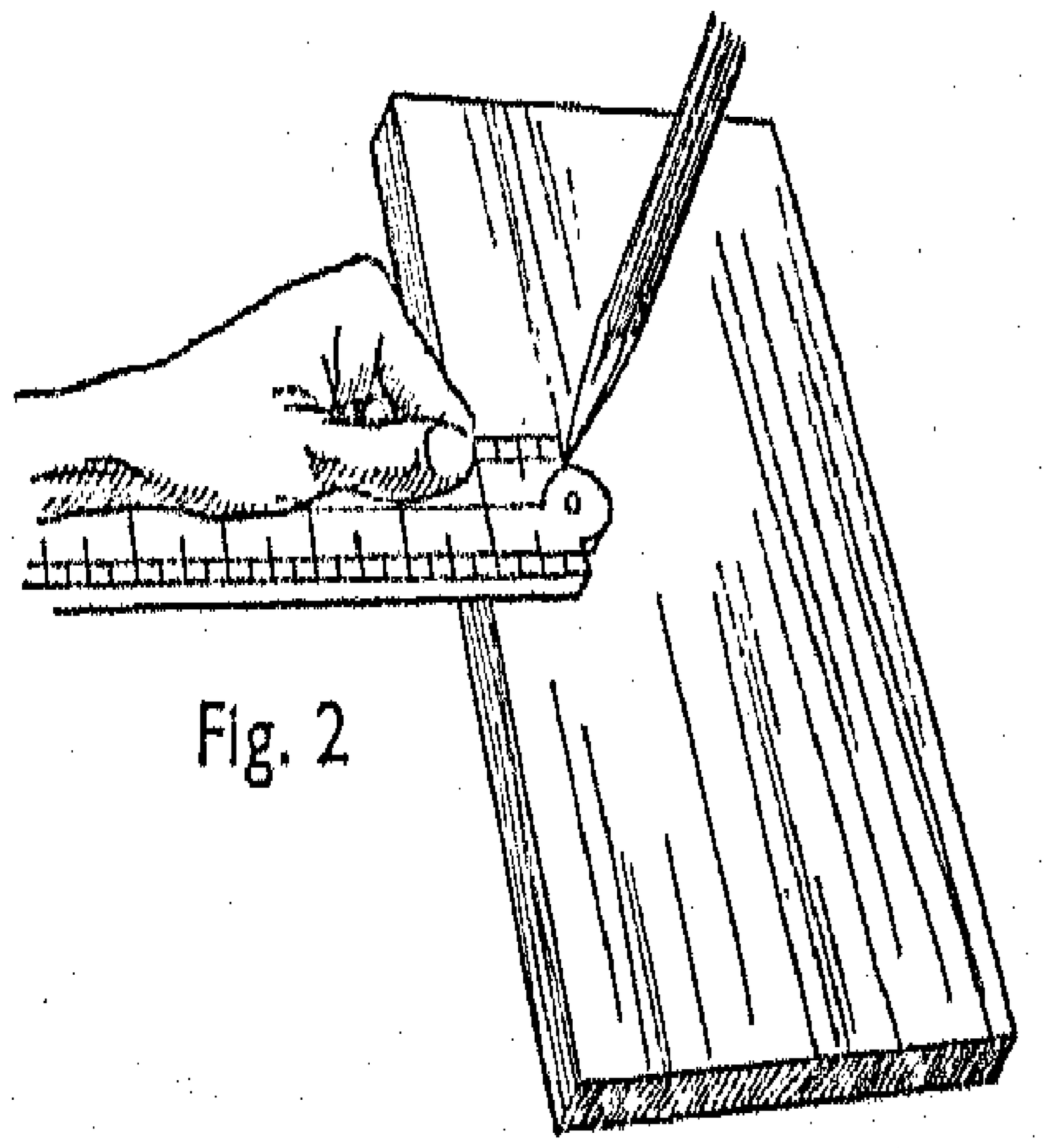
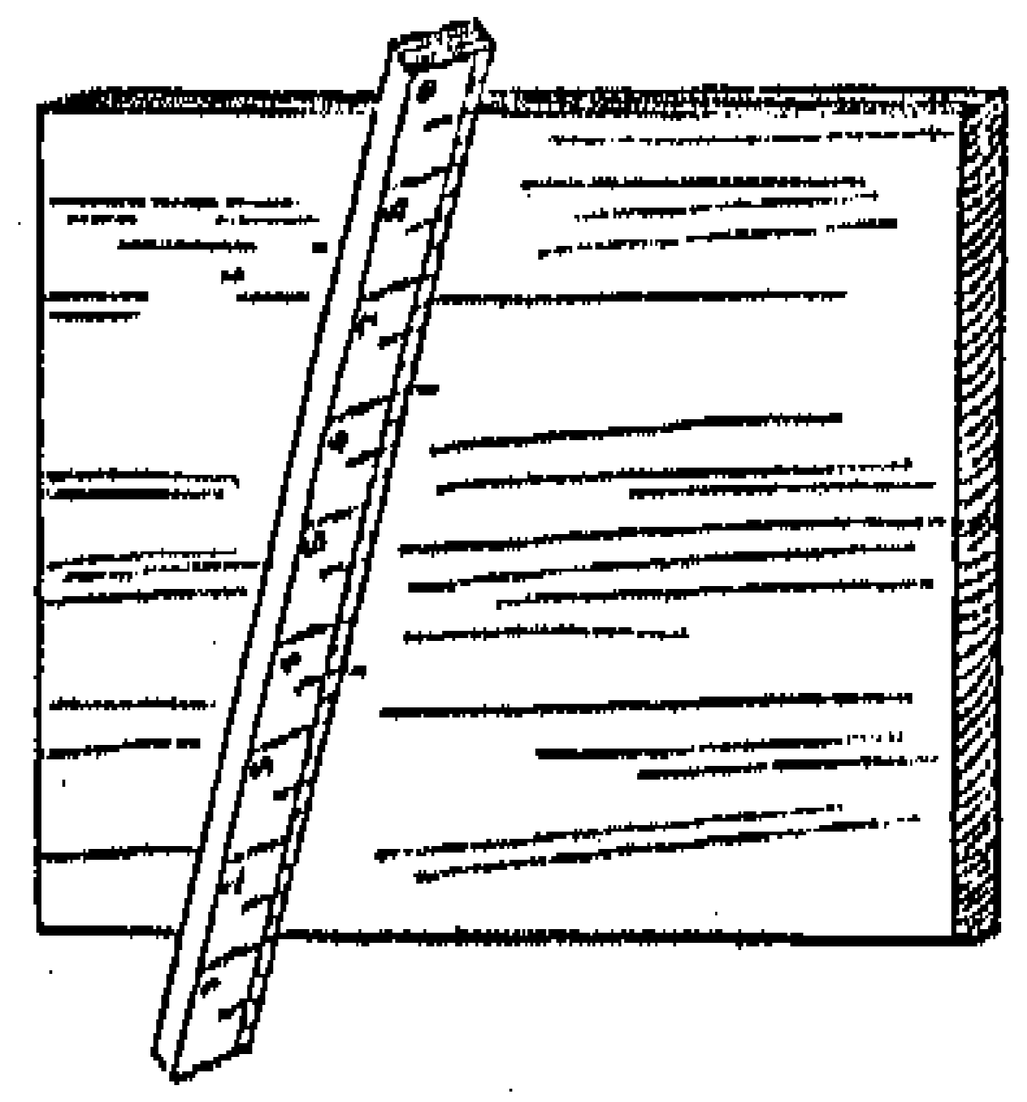


Fig. 2

It is frequently necessary to draw a line parallel to a planed edge of a prepared board as, for instance, in marking out a strip preparatory to sawing. This can be done quite easily by adopting the method shown in Fig. 2. Place the work so that its long edge overlaps the front of the bench by an inch or so, and make a pencil mark at the desired distance from the long edge, near the end. Place the pencil point on the mark and bring the rule, held flatly in the left hand, up to the point, keeping the forefinger up to the edge of the work to act as a guide. Now draw the rule and pencil along the entire length of the board, taking great care to keep the rule at right-angles to the edge.

Fig. 3



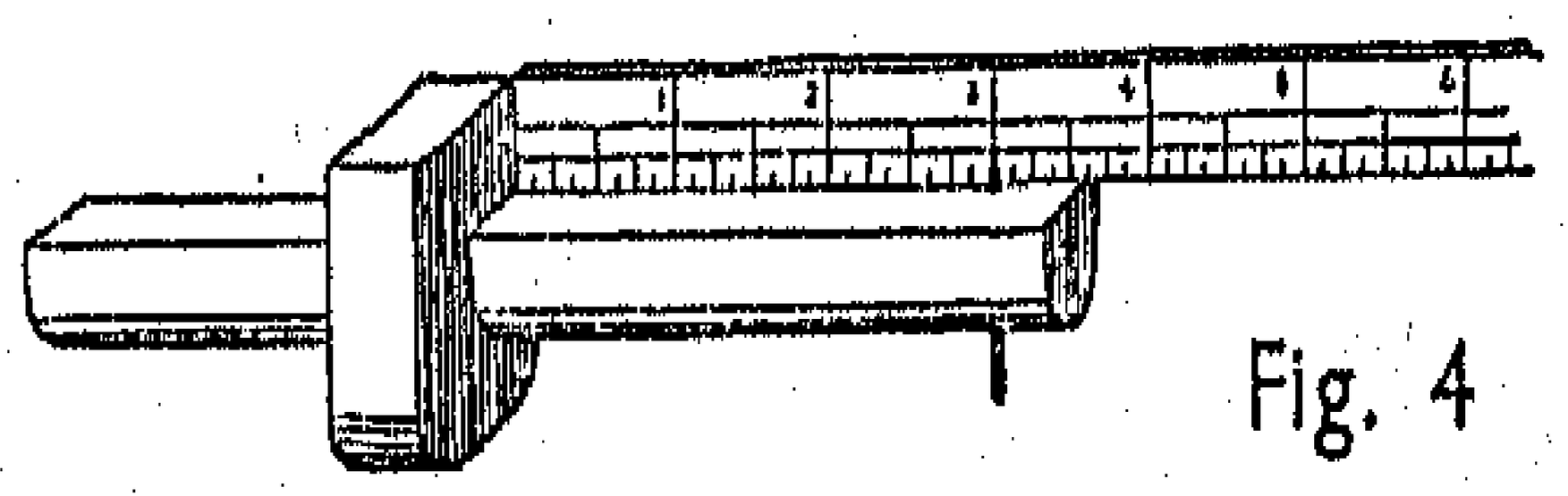


Fig. 4

Marking into Equal Widths.—A quick method of marking a board into a given number of equal widths is shown in Fig. 3. Place the rule on edge obliquely across the surface with one end touching one edge, and at the other a number of inches which is a multiple of the required number of widths, and mark the wood opposite the division mark of each multiple. For example, if a 6-in. board is to be divided into four strips of equal width, then by placing the zero end of the rule against an edge and the 8-in. division on the other, the desired distances will fall at the 2-, 4-, and 6-in. divisions, which give four spaces each 1½ in. wide. Parallel lines are then drawn along the board at these positions.

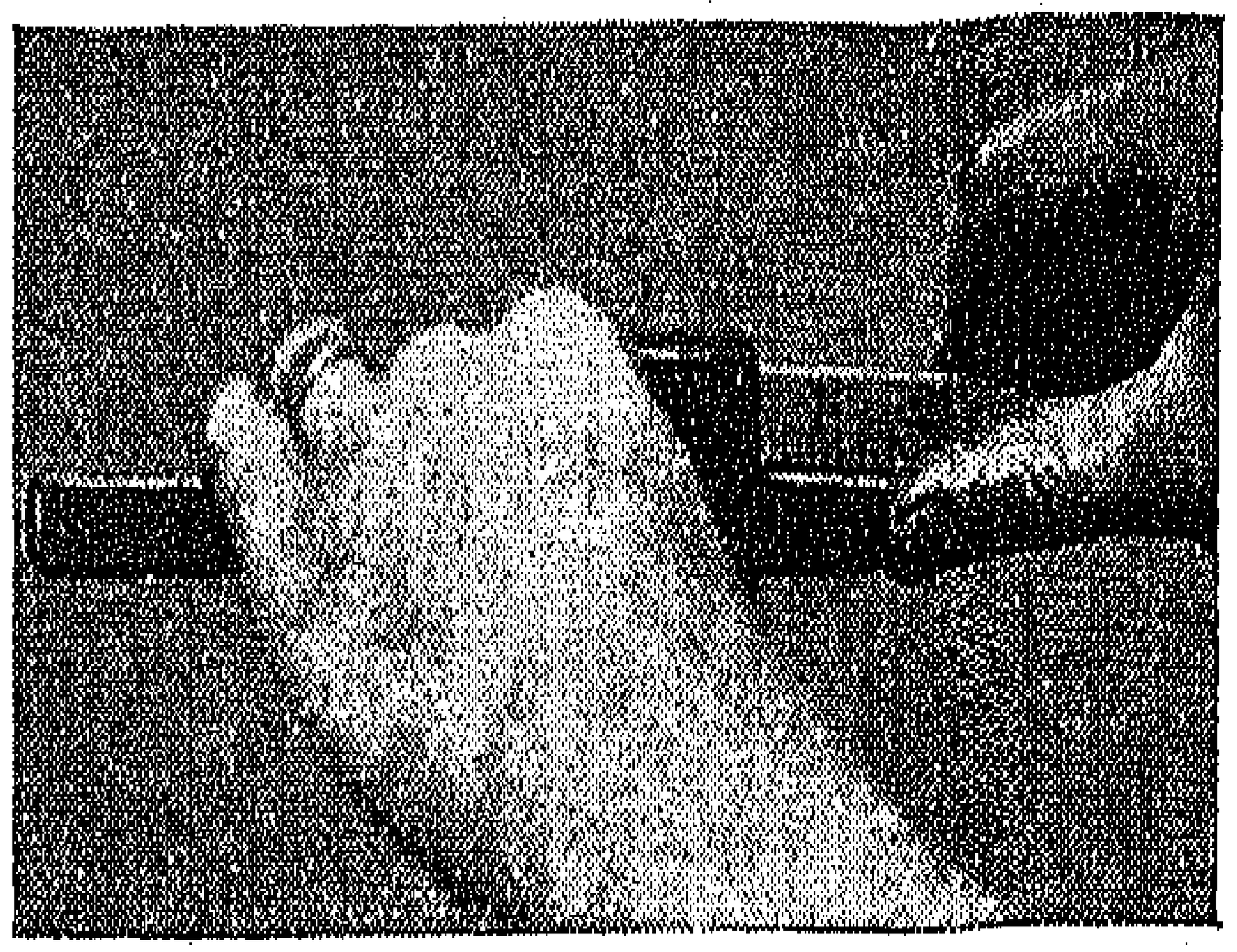


Fig. 5

Similarly, in dividing the same board into three equal widths, the rule would be set across at the 9 in. division and the surface marked at the 3-in. and 6-in. points respectively.

The Marking-gauge (Fig. 4) is one of the most important tools in the setting-out equipment. It is used for marking parallel lines. The gauge is a very simple tool consisting of a hardwood stem having a steel pin near one end for marking the wood, and an adjustable fence which slides along the stem. The fence is set by sliding it along the bar until the distance between the pin point and the fence is equal to the width required, and then locked by a hardwood screw or other suitable device.

Fig. 5 shows the correct way to set a gauge. To do this, first slack off the screw to enable the fence to slide easily along the stem. Hold the bar with the left hand, placing the thumb on the edge of the fence to steady it, and then place the zero end of the rule

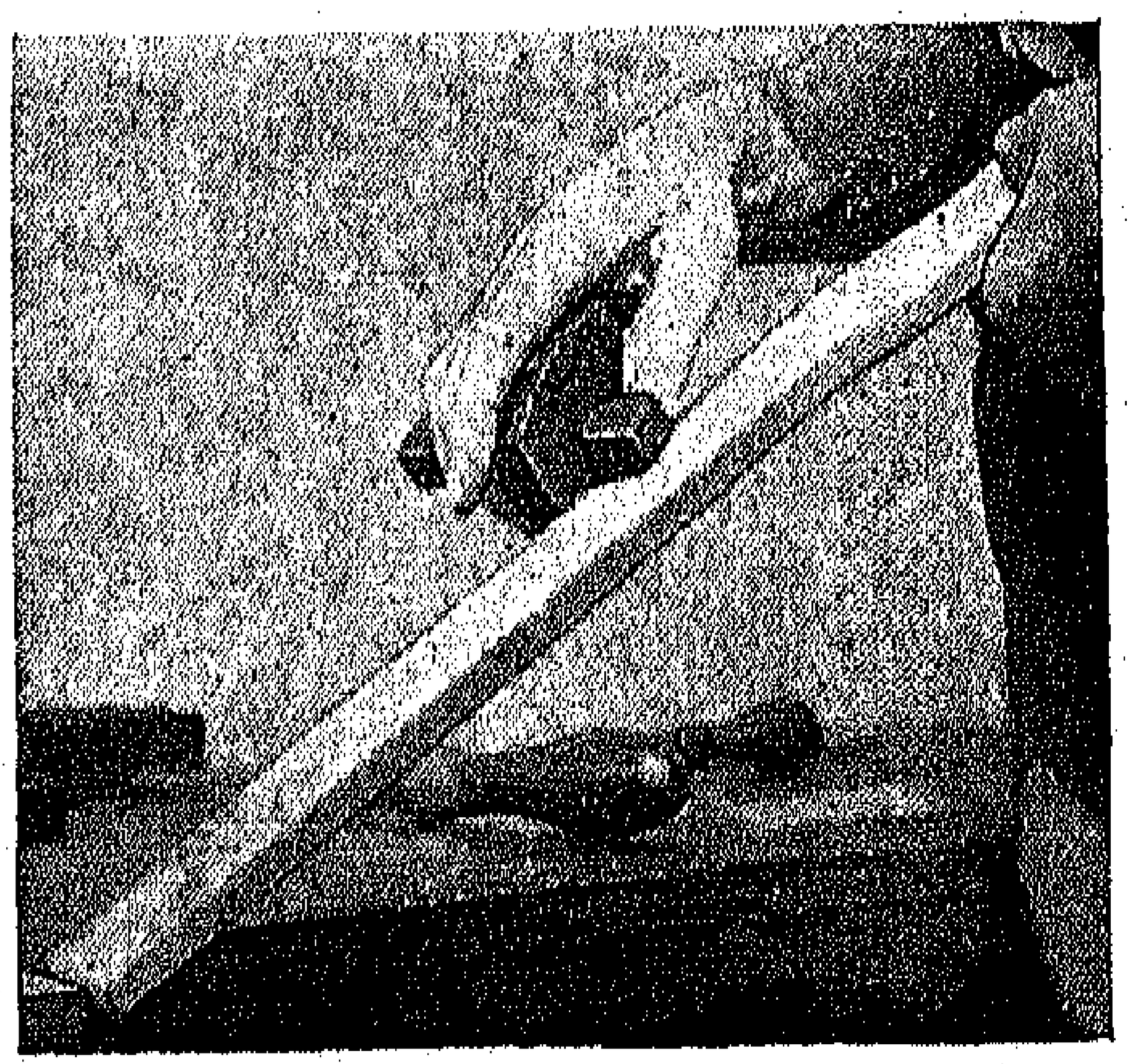


Fig. 6

squarely against the side of the fence, resting the long edge of the rule on the stem. Gradually push the rule along the bar until the required measurement appears opposite the marking point.

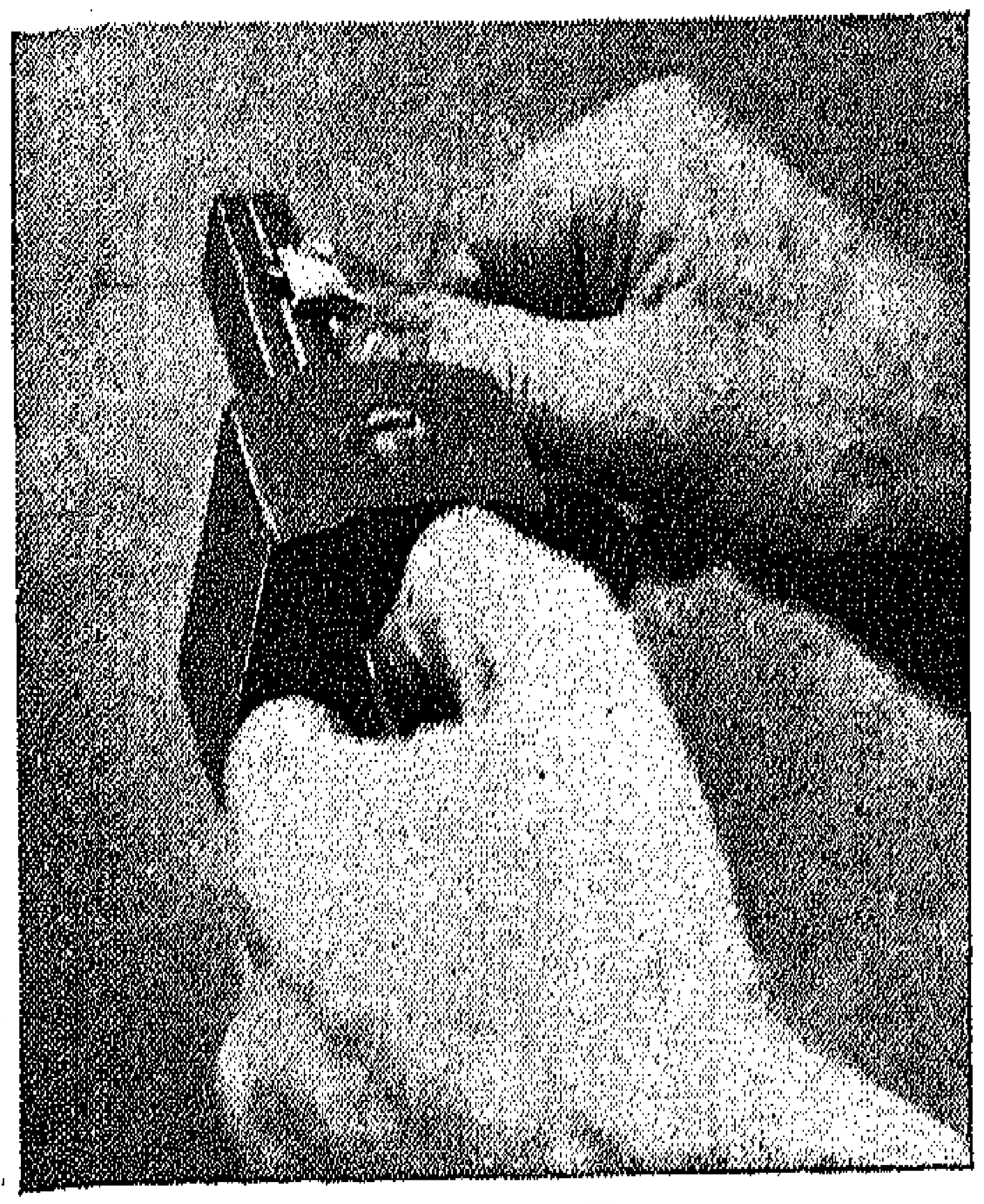


Fig. 7

Keep the fence in this position by pressing it with the left thumb and tighten the screw.

Test with the rule to make sure that the fence has not shifted. If it has, it can be altered a trifle by tapping one end or the other of the stem on the bench. Tap the marking end if the fence has shifted away from the pin, and the other end if it is too close.

A common method of holding and using a marking-gauge is shown in Fig. 6. Rest the end of the work on the bench, but if the wood is not of sufficient thickness to enable the fence to clear the bench-top, place it upon another piece. Hold the tool in the right hand, keeping the thumb behind the marking point, and place the forefinger over the fence to steady it. Now press the fence close up to the edge of the work and push the tool along the work in the direction of the grain, keeping the top of the marking pin tilted slightly forward, so that the point lightly marks the wood. Now repeat the process, applying a little more pressure on the pin. The reason for marking it twice is that if a deep cut is made at the outset the point is liable to follow the grain and consequently mark an imperfect line. It is for this reason also that the fence must always be pressed hard up to the edge of the work.

It should be noted that a marking-gauge should never be used for marking wood across the grain.

A Mortice-gauge is really an ordinary gauge having an additional point which can be adjusted. This allows two parallel lines to be marked simultaneously.

As its name implies it is used for setting-out mortices, the second point being set at the required distance from the fixed one to suit the width of the mortice.

As the width of a chisel used in marking a mortice should be equal to the width of the mortice, the gauge is usually set from the cutting edge of the chisel in the manner shown in Fig. 7. The tool is used in the same way as the ordinary gauge.

The Try-square is used when marking right-angles to the trued edges of wood. In using the tool it is absolutely essential that the stock be held firmly against the work before the scribing-knife or pencil is drawn along the edge of the blade, and that the edge of the work being marked be perfectly straight.

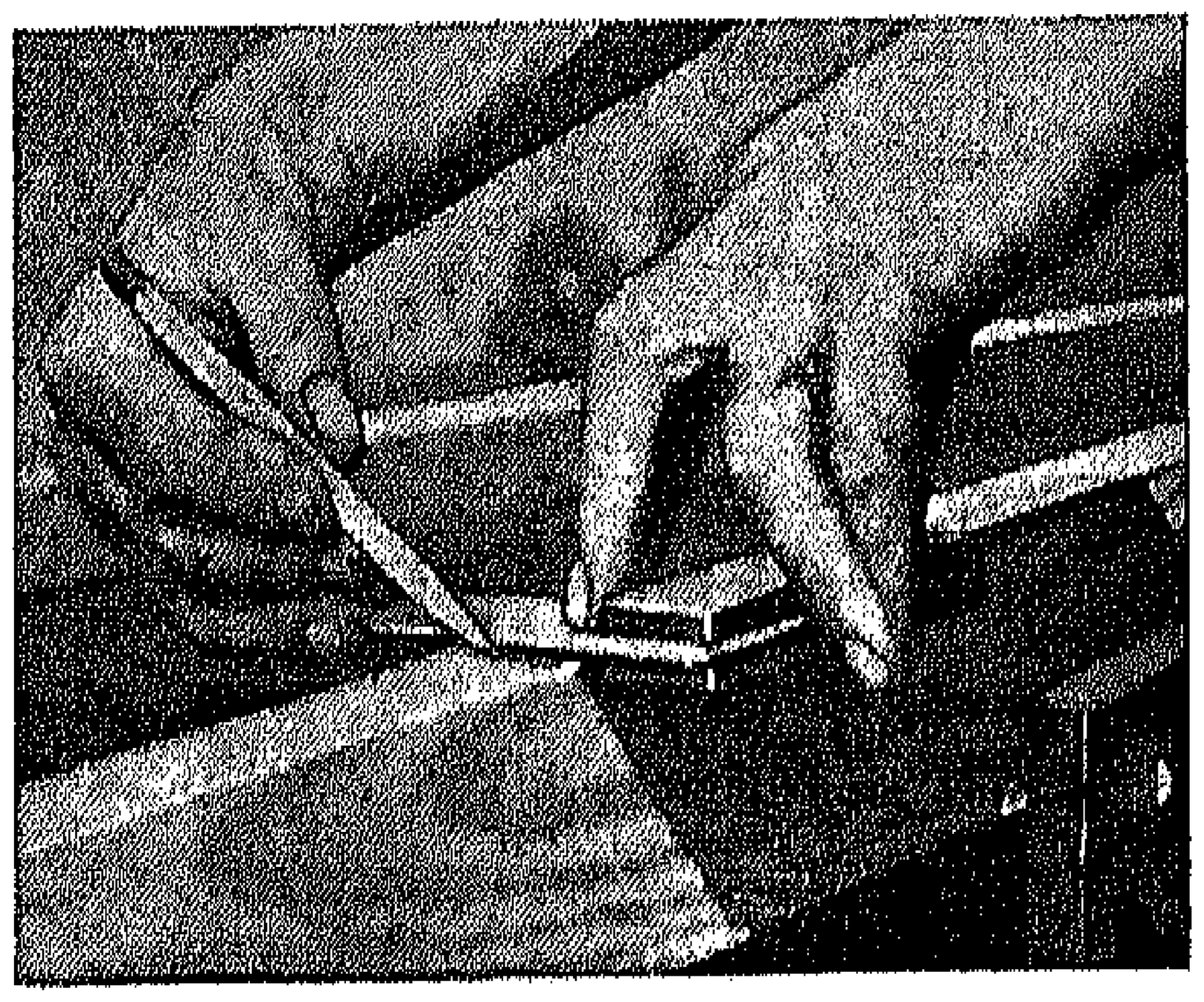


Fig. 8

A square having a 6-in. blade will generally be found large enough for small work, but such a tool is obviously

too small for marking across a 9-in. board.

Fig. 8 shows a square being used for marking a line across a piece of work. To do this, first mark the exact position where the line is to be scribed, then, still keeping the point of the pencil on the mark, slide the square along the edge of the work until the blade just touches the pencil point. Draw the line across, holding the left hand pressed against the back of the stock to keep it in position, as shown clearly in the illustration.

When several pieces of wood of equal size are to be similarly marked, as, for instance, in setting out the stiles or the rails for a cabinet door, it is much better to clamp them together and mark the lot than to mark them individually. This method not only makes for more accurate marking but also saves a great deal of time. When the preliminary guide lines have been marked it is an easy matter to continue the lines round the work where necessary, with the aid of a try-square. Fig. 9 shows a number of pieces being marked simultaneously.

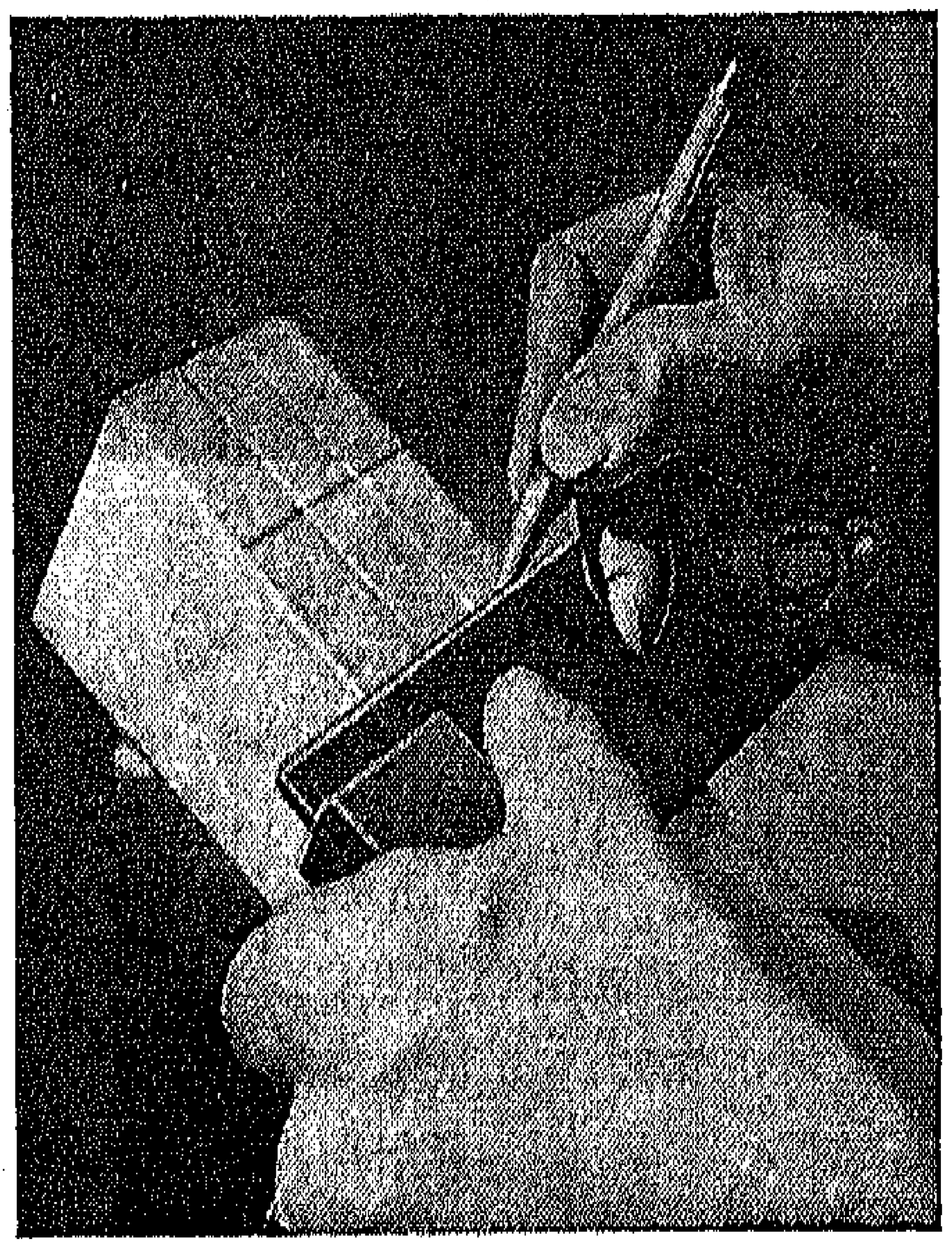


Fig. 9

Do not always take the accuracy of a try-square for granted, because it is easily put out of truth if roughly handled or allowed to drop on the floor.

To Test the Accuracy of a Square, plane up a perfectly straight and true edge on a piece of wood. Scribe a line across the wood in the normal way and then turn the blade over and scribe another line, as shown in Fig. 10. If the square is accurate the two lines should coincide. If the tool is inaccurate the error will be shown doubled by the difference between the two lines.

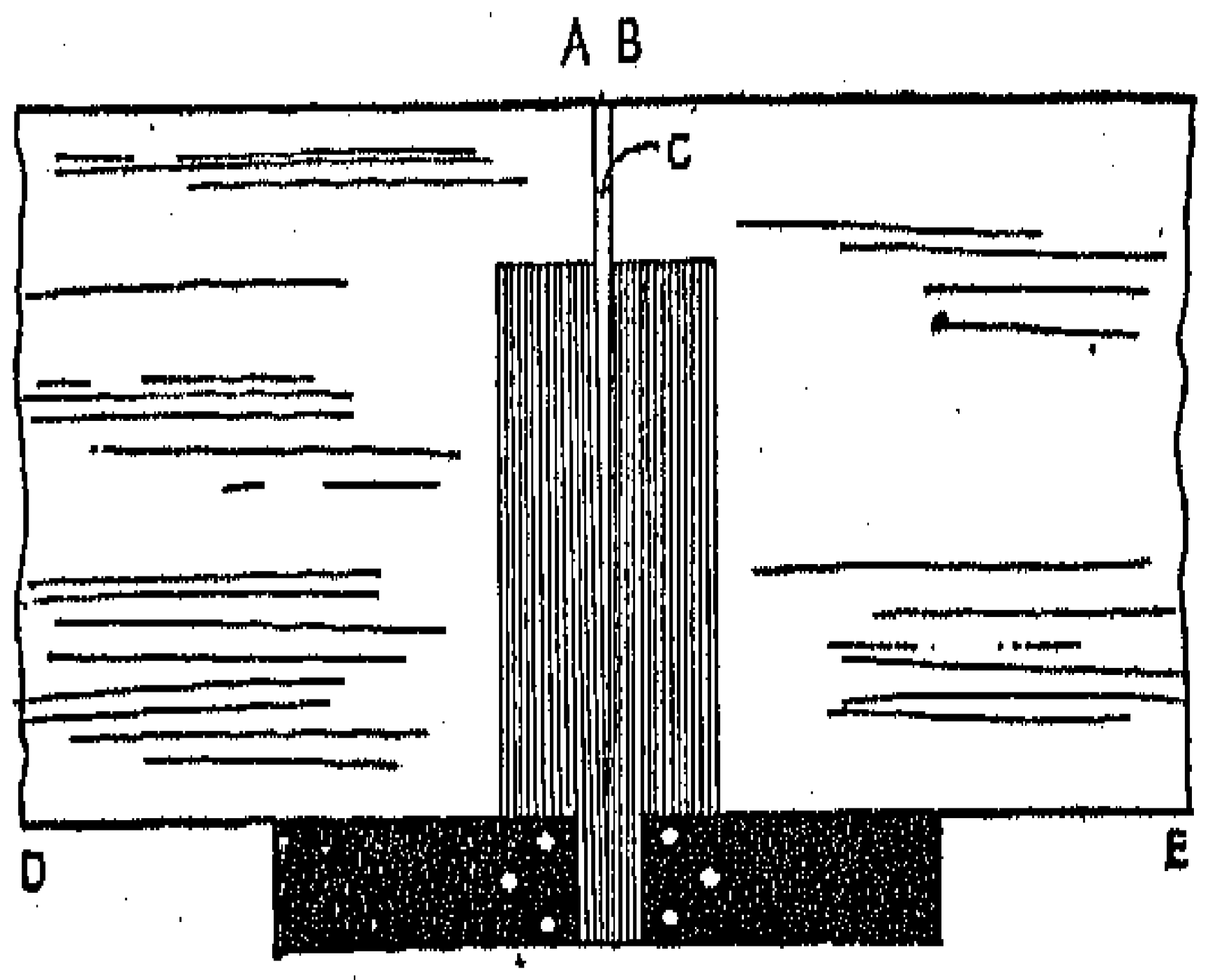


Fig. 10

Thus, in Fig. 10, the line DE represents the true edge of the board, and a line is drawn with the square held in a normal position A, while that at B shows the position of the blade when turned over. The space at C indicates the amount of error doubled.

This error can be corrected by fixing the square, blade horizontal, in the vice and carefully filing the top of the blade from the stock to the other end, using a smooth file for the purpose. The first stroke should be short and each succeeding stroke a trifle longer. Do not make a heavy cut, and take care to keep the file almost parallel with the edge of the blade. Test frequently and when true, remove the tool from the vice, and finish off the edge on an oilstone or rub it gently, lengthwise, on a piece of fine sandpaper laid on a true surface. The same operation must be carried out if the blade is full at the other end,

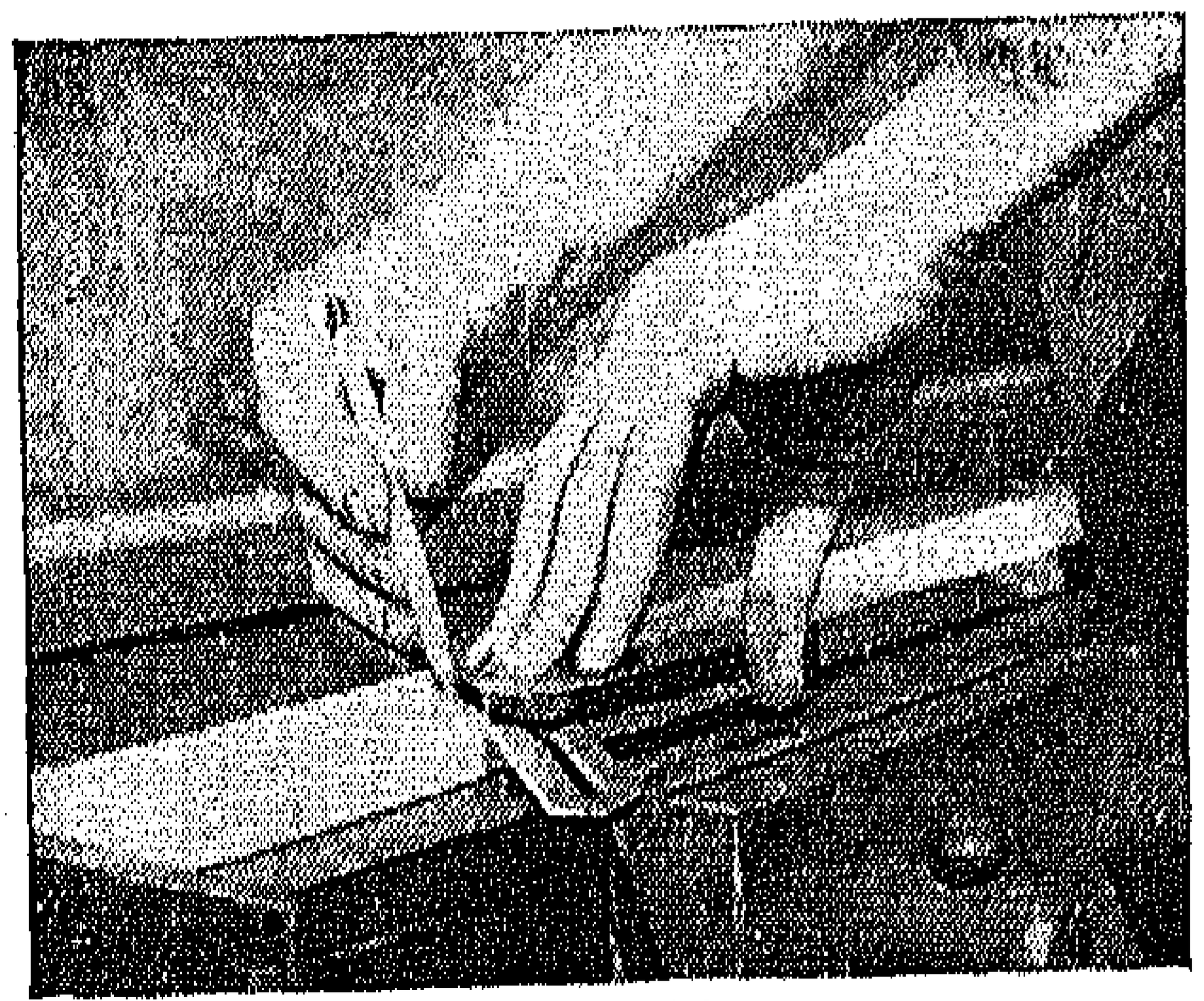


Fig. 11

but, of course, that end gets most attention.

The Adjustable Bevel is used for setting-out and testing angles on work. The tool in use is shown in Fig. 11. It is similar to the try-square except that the stock is narrower and slotted at the top to accommodate a thin parallel-edged blade which is also slotted. The blade is held securely in position by means of a screw passing through the stock and the slot in the blade.

To set the bevel, first slack off the fastening screw a trifle so that the blade is not too slack in the stock; and adjust the blade to the desired angle, and tighten up the screw. Test for accuracy, as the blade may have shifted a trifle whilst being tightened up. Should any slight inaccuracy be detected, tap the blade on a piece of wood and again verify. The tool is then used in the same way as the try-square, care being taken to keep the stock pressed tightly against the edge of the surface to be marked.

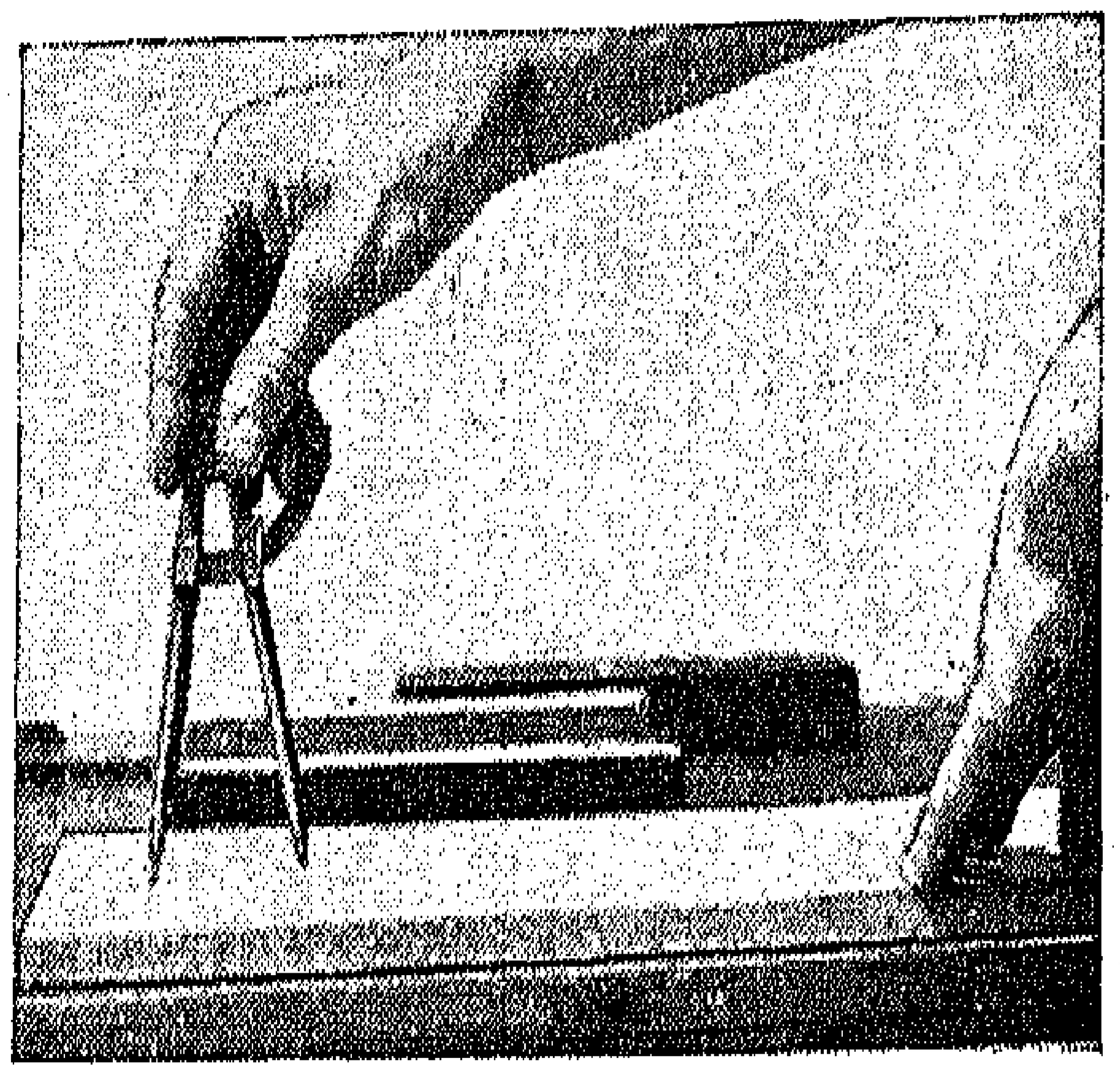


Fig. 12

Dividers are useful for transferring measurements from one piece of work to another, and from the rule to the work. The tool is also handy for dividing the distance between two given marked points into equal parts, where it could not be conveniently done with a rule. To use the dividers for this purpose, the trial and error method is adopted. The legs are first opened to approximately the width of one division, and then stepped across the work between the two marked points. If the distance between the points of the dividers does not exactly divide into the overall dimensions they should be reset and again tried until the number of steps does divide equally into the marked positions.

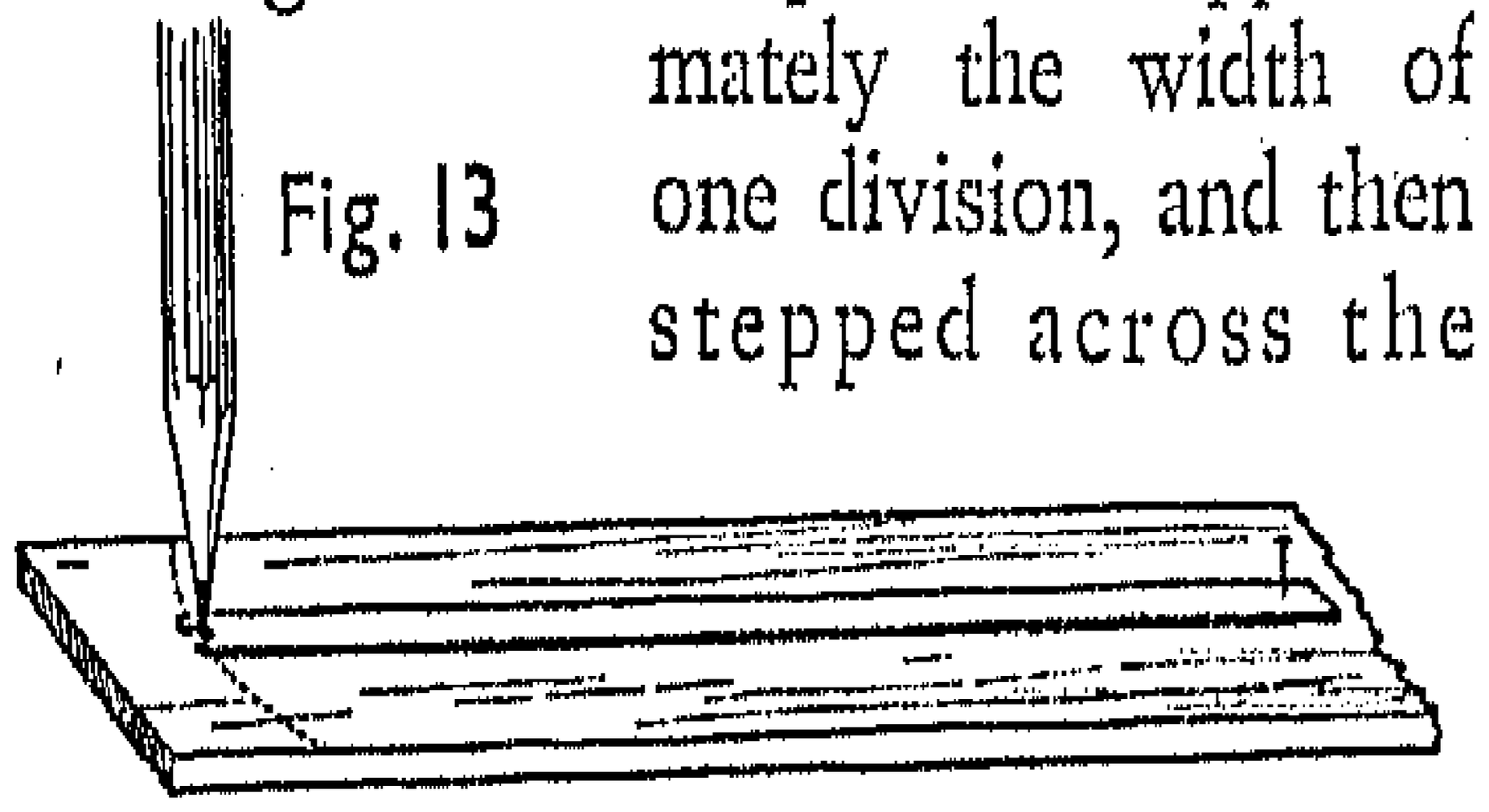


Fig. 13

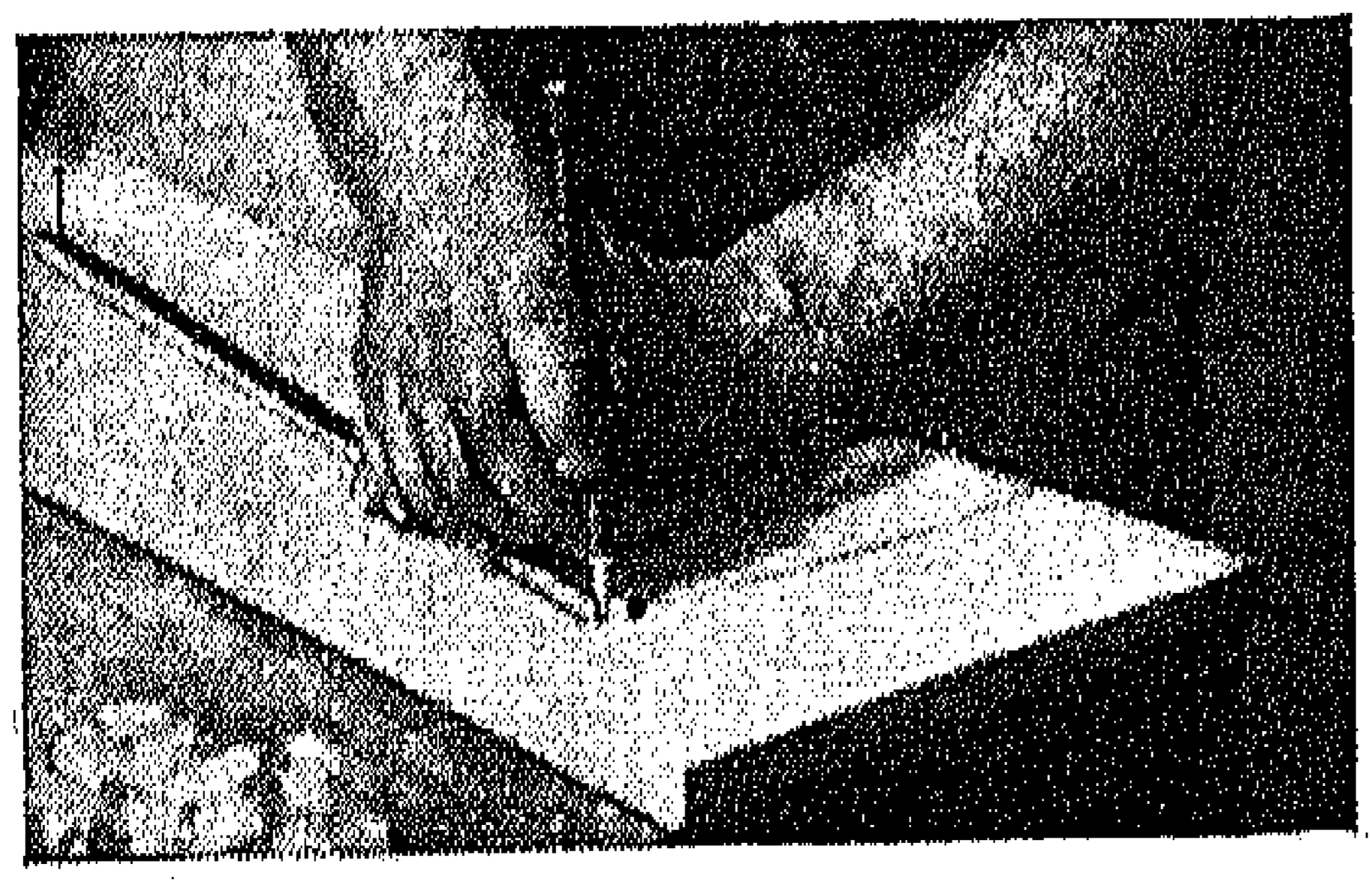


Fig. 14

In the absence of compasses, dividers may be used for scribing circles and curves. The legs are first opened to correspond to the radius required and the point of one leg is placed on the centre-mark of the circle or arc to be described, as shown in Fig. 12. The tool is then held at the top and twisted round so that the point of the other leg lightly marks the work.

If the point at the centre is likely to make an undesirable mark on the work a thin piece of wood should be interposed, taking care that it does not slip. If this is likely to happen, place a piece of sandpaper rough side down on the work and moisten the underside of the wood.

A Home-made Beam Compass.—The professional generally uses a beam compass or a trammel for scribing large circles or curves. This can be improvised out of a thin strip of wood a little longer than the desired length of the radius of the circle or curve. A notch is made at one end to guide the pencil point, and a thin nail is driven through the lath near the other, at a distance from the pencil-point equal to the radius required. To use the device, all that is necessary is to drive the nail lightly into the work at the desired centre, place the pencil point into the notch, and move the lath round. This simple yet effective contrivance is shown in Figs. 13 and 14.

It frequently happens that a number of small pieces of the same size and shape have to be marked out. In all such cases an enormous amount of time will be saved by making a template and using it as a guide in marking out. For instance, in marking out dovetail pins, a piece of thin sheet zinc or brass can be cut out with an old pair of scissors to the exact size and shape of the pins, as illustrated in Fig. 15. The template can then be used as a guide for the point of the marker so that each pin is exactly the same size. The same thing applies for larger work, or for the marking of awkward corners. In a great many instances stiff cardboard could be used with advantage instead of sheet metal.

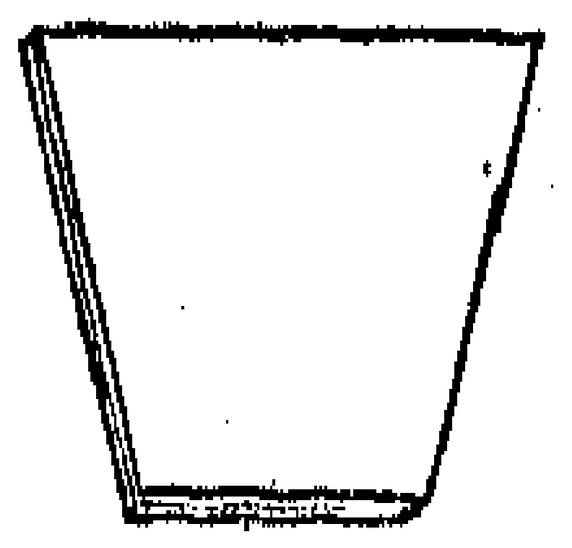


Fig. 15

NAILS AND SCREWS

Although there are many methods of fastening pieces of wood together, such as gluing, dowelling, wedging, etc., nailing and screwing are possibly the ones most commonly used by the amateur.

Nails are made in numerous shapes and sizes, each designed to suit a particular purpose. The novice should, therefore, get familiar with the commonest sorts of nails and screws so that he will then be able to choose the correct fastener to suit his purpose.

Types of Nail.—Fig. 1 from A to I shows a few types of nails for what may be termed everyday use.

That shown at A represents an oval wire nail, so called because its shape is practically oval and it is made from wire. It is an excellent nail for general purposes, has good gripping power and does not split the wood, provided it is driven in with its largest diameter parallel to the grain. As it has a small head it can be punched under the surface without leaving an unsightly hole. Oval wire nails can be obtained from ½ in. to 6 in. in length, the thickness varying with the length.

The French or Round wire nail illustrated at B may be obtained from 1 in. to 10 in. in length. It is used for more or less rough work and has great holding power. A French nail has a larger head than an oval wire nail and as it is more robust it does not bend so easily. Owing to the large size of the head it cannot be sunk below the surface.

A Cut Clasp Nail is illustrated at C and, as will be seen, it is an entirely different kind of nail to the wire as it is punched from sheet metal. It is more or less rectangular in section and tapers in its width from the top of the shank downwards, terminating in a blunt unpointed end. Like oval brads, clasp nails are driven in parallel with the grain of the wood.

The nail shown at D is a floor brad specially designed for nailing down floorboards.

The illustration at E represents a wrought clasp nail and these were once made by hand. It has the advantage that it is more flexible than the cut nail, which makes it particularly useful for clinched work, that is, where a nail is driven through two pieces of wood and its end knocked over or clinched on the reverse side. Owing to the high cost of manufacture it is seldom used.

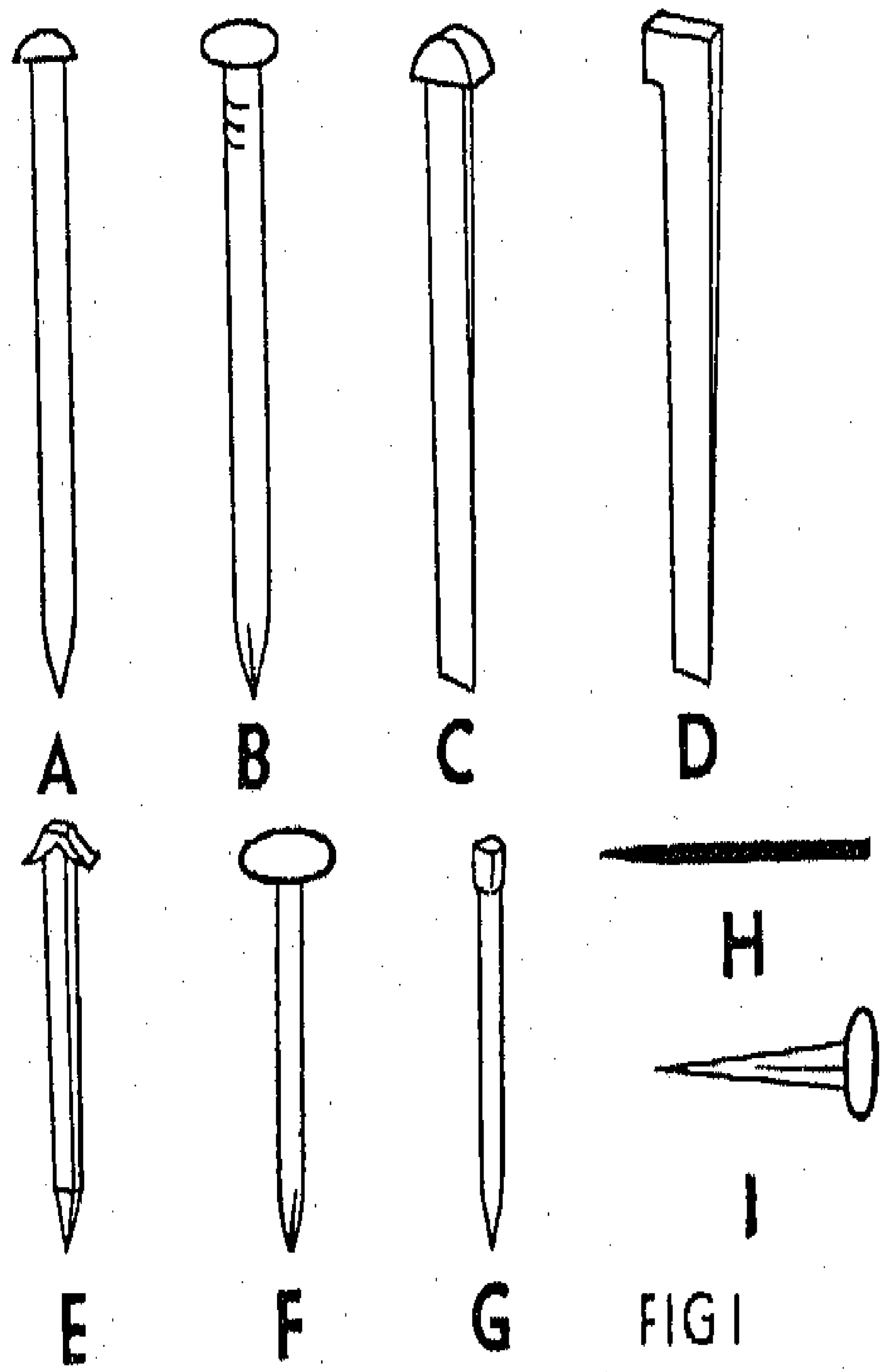


FIG I

A Clout Nail (F) has a thin flat head which is larger compared with its length than any of the nails previously referred to. This feature makes it particularly useful for fastening down roofing felt. When used for outdoor work the galvanised kind should be employed.

Panel Pins are an extremely useful kind of fastener from the amateur's point of view. They are made from very thin wire and have a tiny head which makes them extremely handy for fastening small work, such as beadings, etc. They may be obtained in sizes varying from $\frac{1}{2}$ in. to 2 in. in length. A panel pin is shown at G.

Needle Points, shown at H, are used for fastening very small work. They are headless and brittle. In use they are driven partially into the work and a tap on the side with a hammer breaks off the projection flush with the surface, which makes them practically invisible.

Tacks, represented at I, are a form of small nail with a very sharp point and fairly large head. They are used more for household purposes, such as fastening down carpets and the like, than for woodwork.

When nailing two pieces of wood together where the top piece is thinner than that at the bottom—as indicated in Fig. 2—a nail nearly three times as long as the thickness of the top piece should be employed. Thus if the upper piece is 1 in. thick, a nail at least $2\frac{1}{2}$ in. in length should be employed. This is an arbitrary figure, however, and cannot always be adhered to.

In cases where a piece of wood has to be fastened to another piece with the nail going into the end grain, in the manner shown in Fig. 3, a longer nail than that previously mentioned is necessary, as nails do not grip so well in the end grain. For example, if the thickness of the top piece is 1 in., a 3-in. nail would be the minimum size to use.

When fastening two pieces of wood of equal thickness together, a nail a little longer than the combined thicknesses can be used. This allows the ends of the nails to be hammered over or clinched, as shown in Fig. 4. The proper way to do this is to drive all the

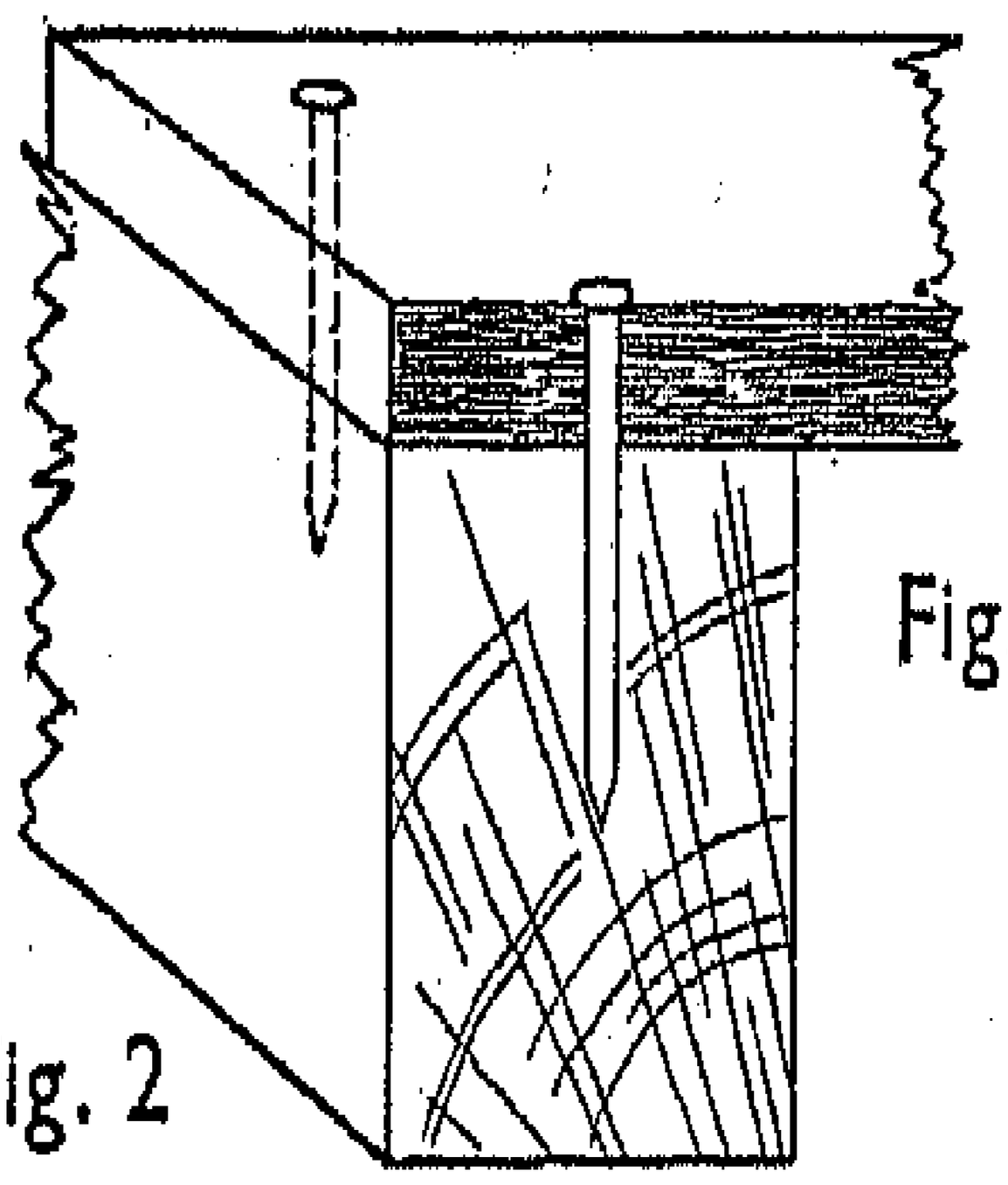


Fig. 2

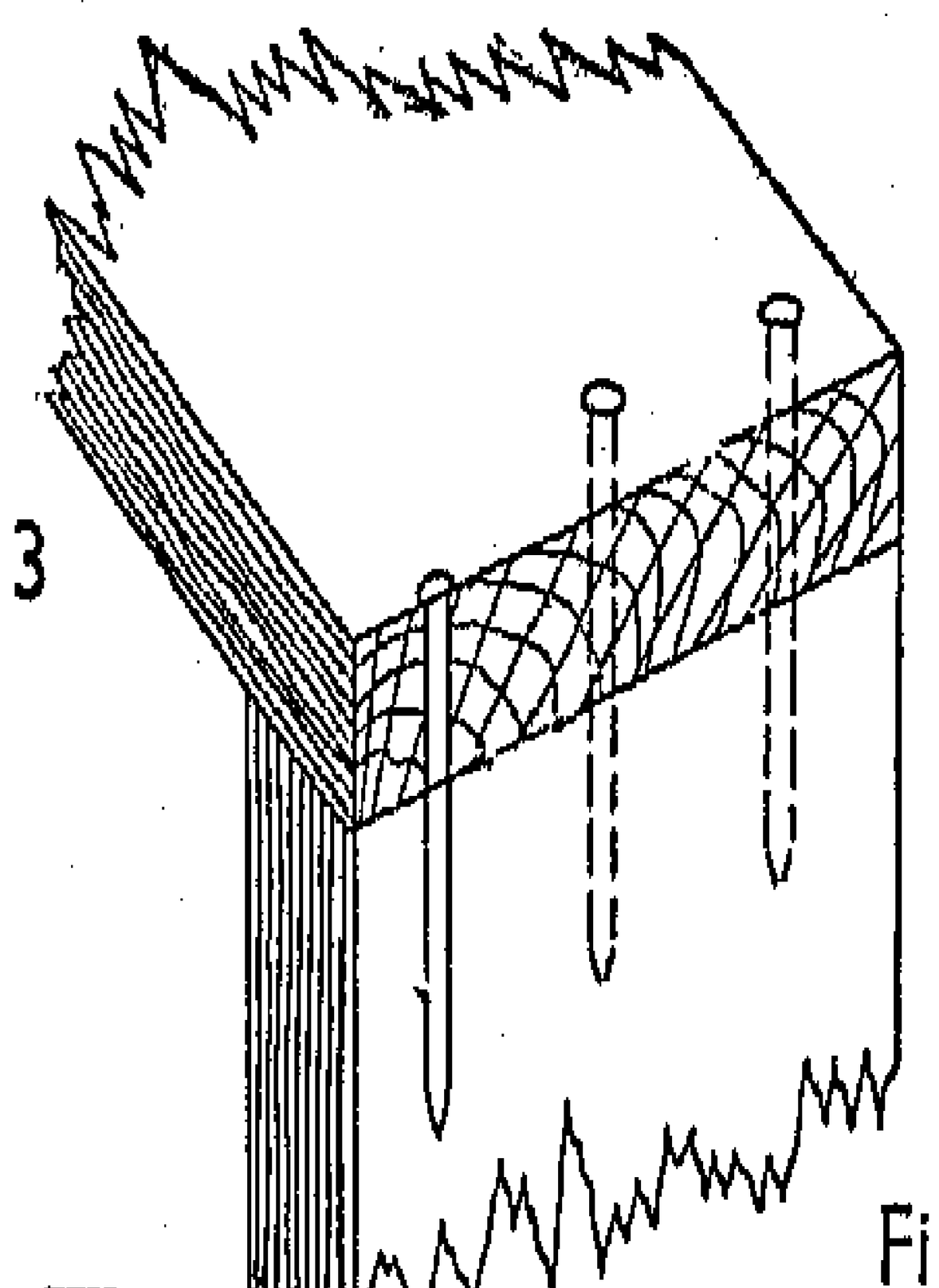


Fig. 3

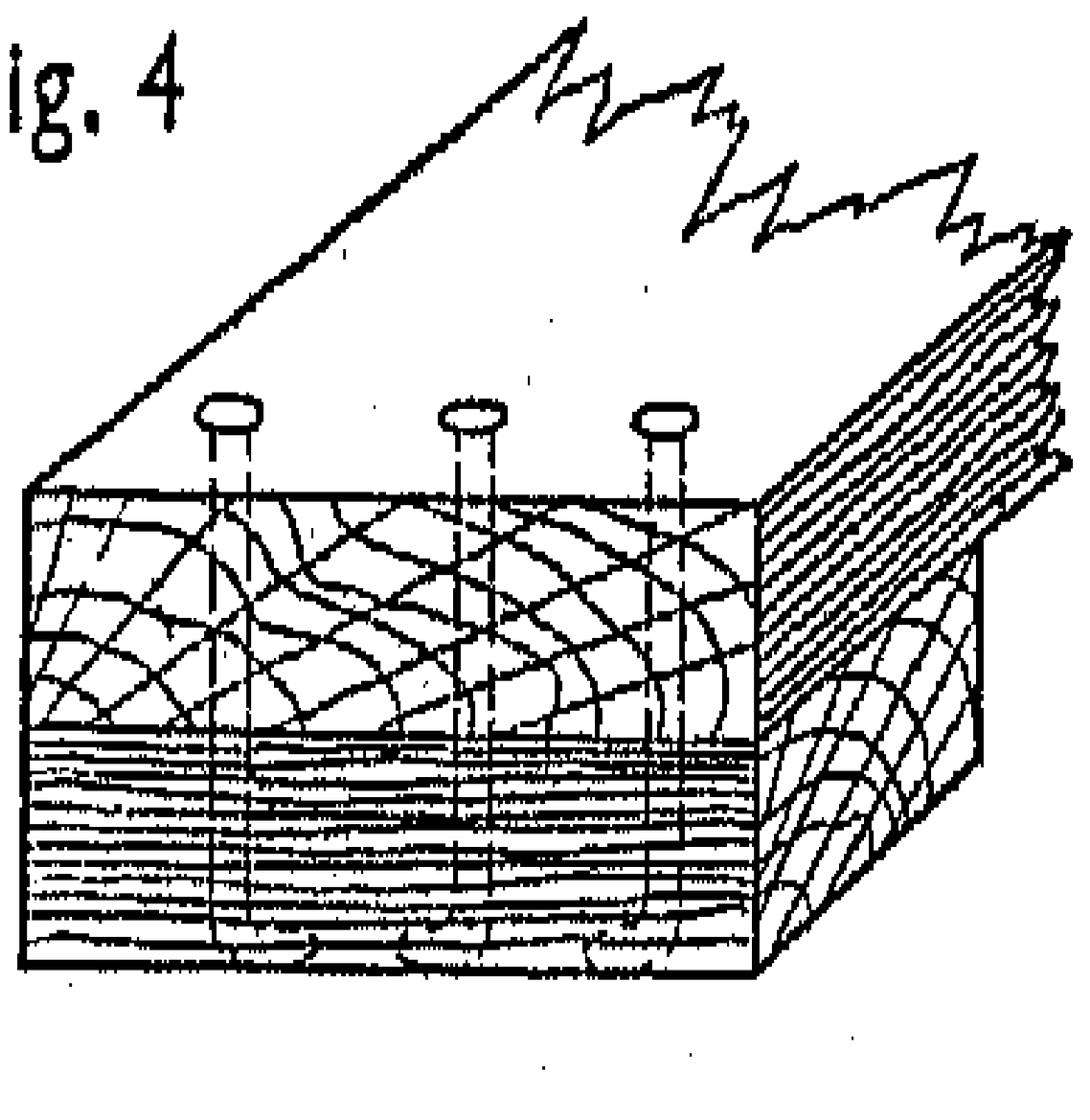


Fig. 4

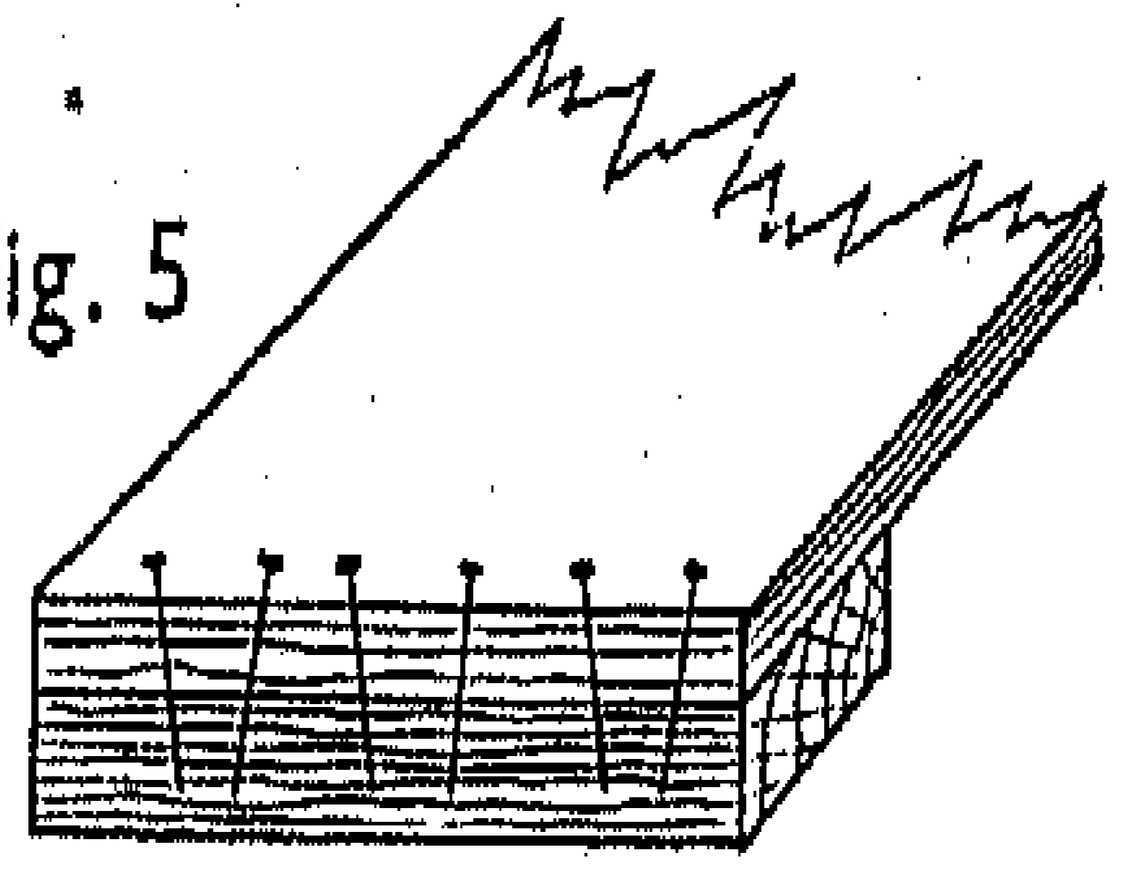


Fig. 5

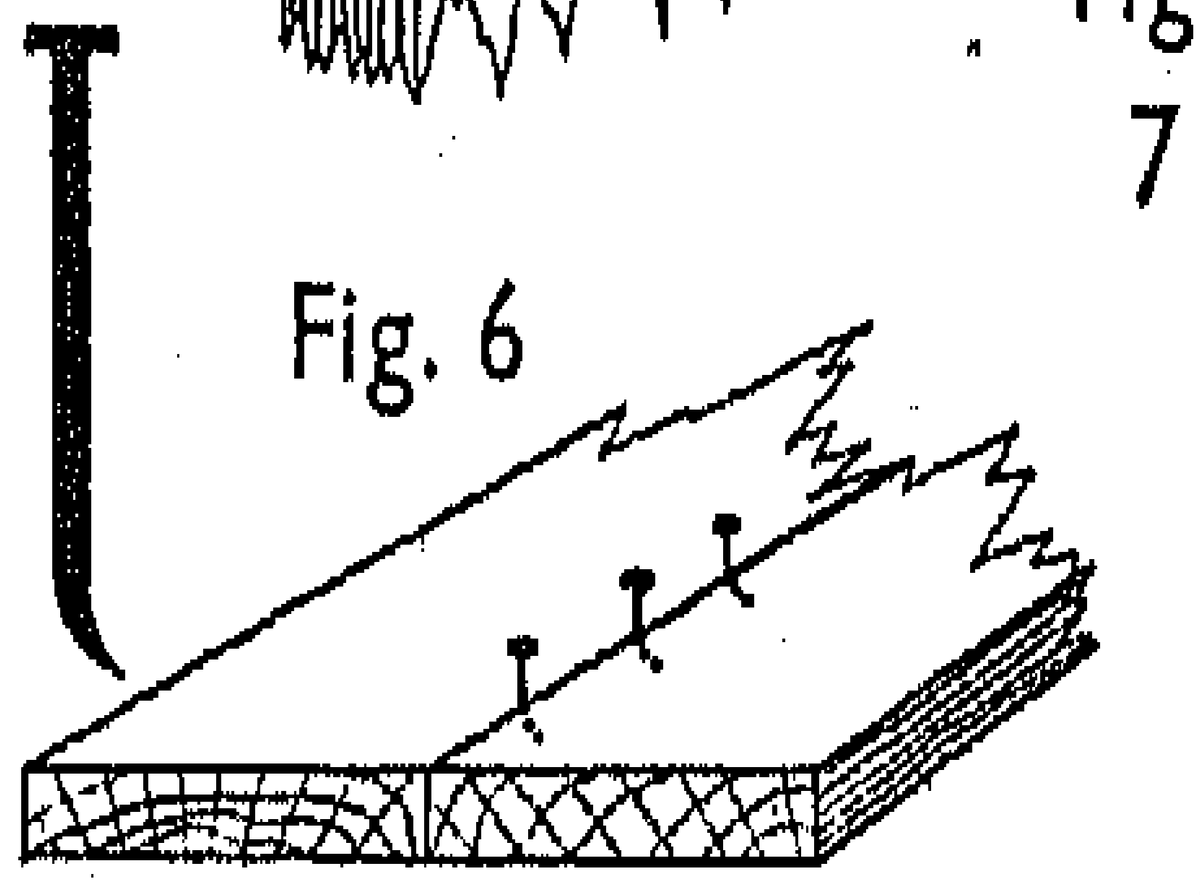


Fig. 6

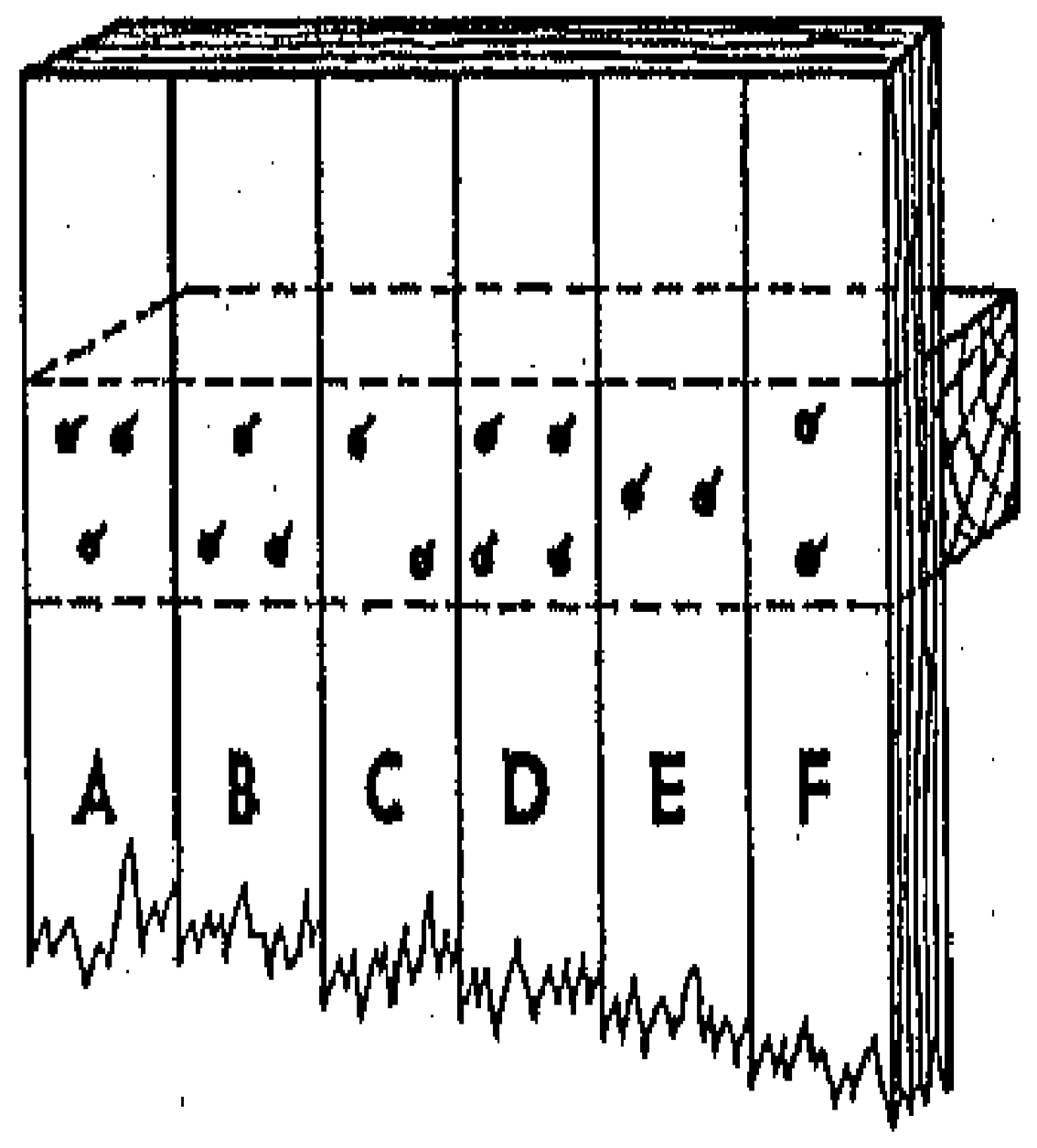


Fig. 7

nails in first, turn the work upside down and hammer over the ends by striking them on their sides. To prevent the heads from being driven back, the heads should rest upon a piece of heavy metal, such as an anvil, or, failing this, a domestic flat-iron fixed sole upwards in the vice will generally answer the purpose.

In the event of the clinching method being objected to on account of its unsightliness on the back face, the nails should be driven in at an angle to form "dovetails," as indicated in the drawing at Fig. 5.

Fig. 6 shows a method of making a nailed butt joint. Before inserting the nails bend them at the tip as indicated.

Hammering.—When driving a nail do not forget that a series of smart taps at the finish is better than heavy blows and less likely to damage the wood. The hammer should be held near the end of the shaft and used from the wrist and not the arm.

Always bore holes where nails are to be driven in near the end of a piece of wood to avoid splitting. These may be bored with a sharp bradawl, but when using a bradawl see that its cutting-edge cuts across the fibres of the wood and not with it. If the nails are large ones make the holes with a twist-drill, the diameter of which should be smaller than that of the nail. Nails should never be driven into hardwood at whatever positions they may be required without drilling holes first.

Fig. 7 shows three common methods of nailing boards to a supporting batten as, for instance, in fastening matchboards to a cross-piece or ledge of a door. The main object to be aimed at in dealing with work of this description is to arrange the positions of nails in such a way that they do not split the boards or the support, and to ensure that the whole width of the board makes good contact with the cross-piece.

From the above it follows that those at A, B, C, and D fulfil these conditions, while those at E and F do not.

In good work it is usual to sink the nail-heads a little below the surface and then fill the cavity with one of the various fillers, such as plastic wood.

A Steel Nail Set or **Punch** is used for sinking nails; illustrations of these appear at A and B in Fig. 8. Nail punches may be obtained in rectangular or in round section steel, the former

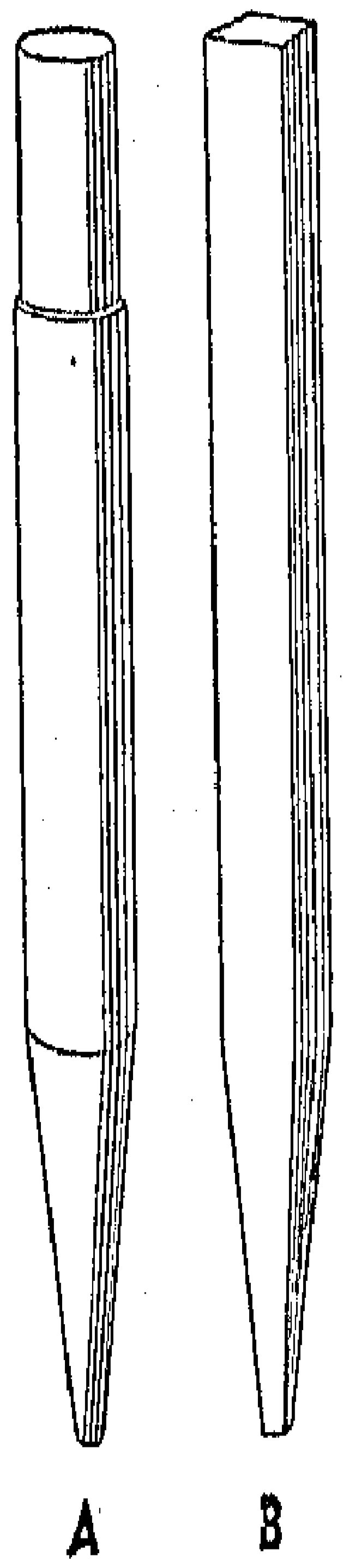


Fig. 8

having small flats on its tapered end while the end of the latter is cup-shaped to prevent it slipping off the head of the nail. It is a good plan to have two nail sets: one of the rectangular type for large nails and a round one for small.

The Punch is used by presenting the tapered end to the head of the nail and giving it a slight blow with a hammer, driven in the same direction as the nail. Fig. 9 shows a nail set in use.

Fig. 10 shows a method of hiding a nail head, called secret nailing. It is used in high-class work where a nail-head, even if punched below the surface and "stopped," is objected to. To carry out this process all that is necessary is first to lift a tiny portion of the surface of the wood in the direction of the grain with a sharp narrow chisel, at a point where the nail has to enter. Then drive the nail in and bury the head by punching it down. Glue down the raised strip and, when dry, sandpaper the surface or run a very finely set smoothing plane over it.

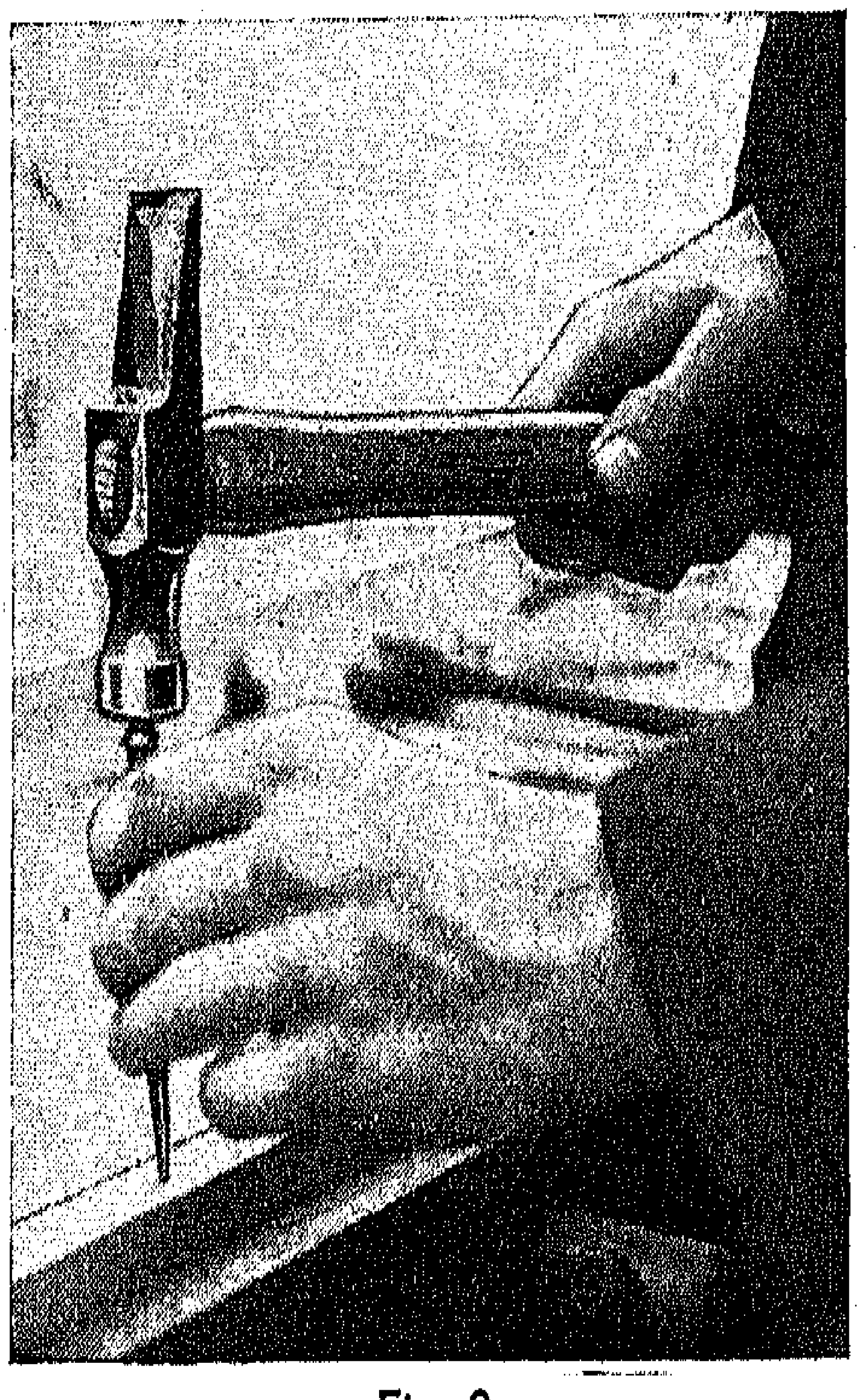


Fig. 9

In nailing, it sometimes happens that the hammer-head slips off the head of a nail and dents the wood. This is not always due to bad workmanship, but very often caused by the face of the hammer becoming greasy and dirty. When this occurs, clean the striking face by rubbing it on the floor.

Hammer Marks are difficult to remove, but if the dent is treated at once with water, allowed to dry thoroughly and then levelled over with sandpaper, the water may have swelled the wood sufficiently to make the fault almost invisible.

As it is sometimes necessary to withdraw nails, do not forget to use a piece of wood between the work and the jaw of the pincers, as illustrated in Fig. 11.

Screws are used where greater strength is required than that produced by nails, and where the parts to be fastened are likely to be taken to pieces at some future time.

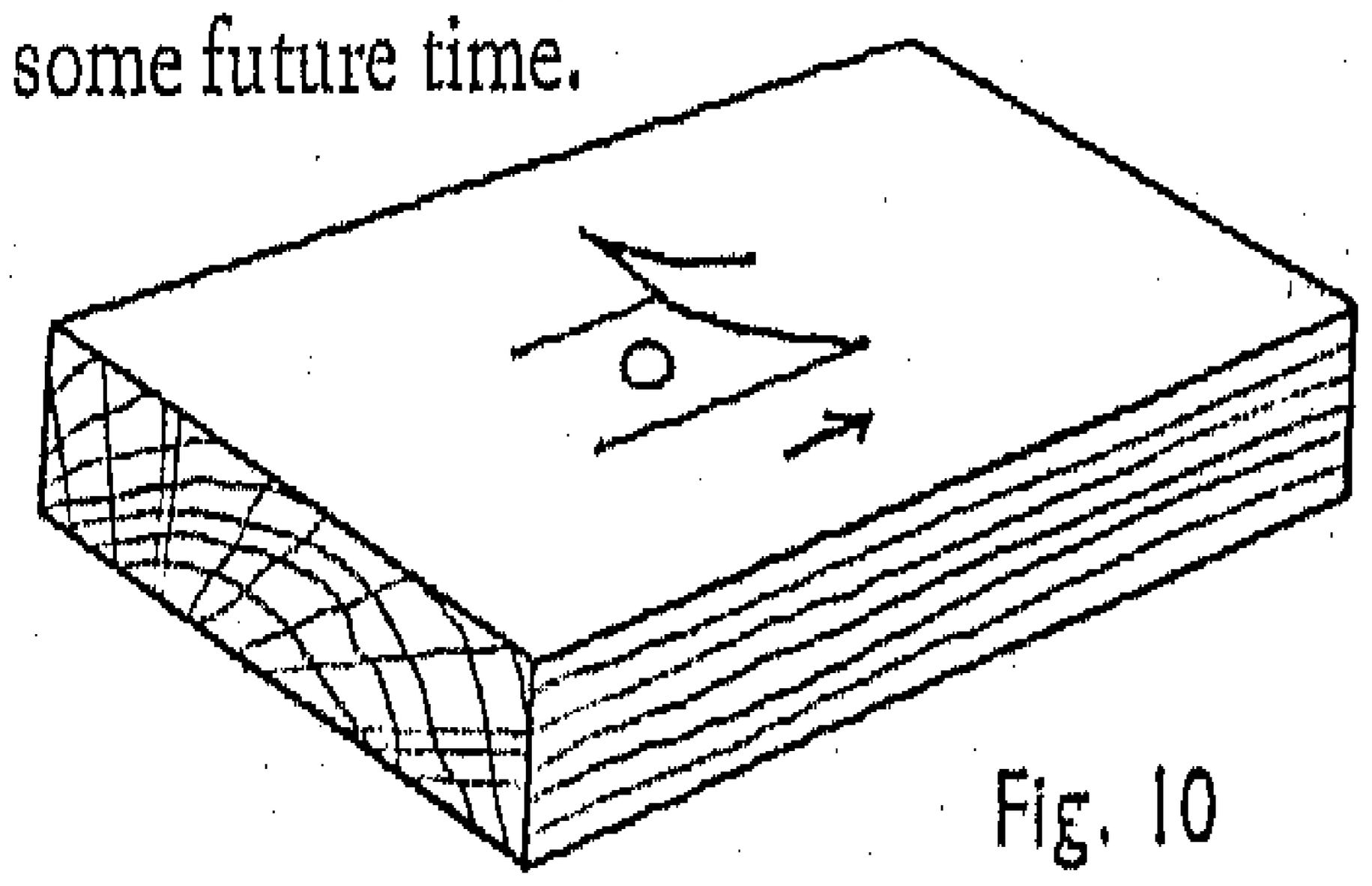


Fig. 10

The screw is very much more powerful in holding the parts together and drawing the parts tightly to one another. It is based on the principle of the inclined plane, one of the most powerful of the mechanical forces.

Screws, like nails, are made in numerous sizes, but the difference of shape is generally confined to the heads.

The commonest types of screws are made of iron or brass, while copper and gun-metal are used for screws for special purposes.

The most frequently used screw is possibly the countersunk-headed screw, shown at A in Fig. 12. It is employed where a flush surface is required. The round-head screw illustrated at B is used mainly for fastening fittings, such as locks, door-bolts, etc., where countersunk-headed screws could not be conveniently employed, and in cases where the wood is too thin to countersink.

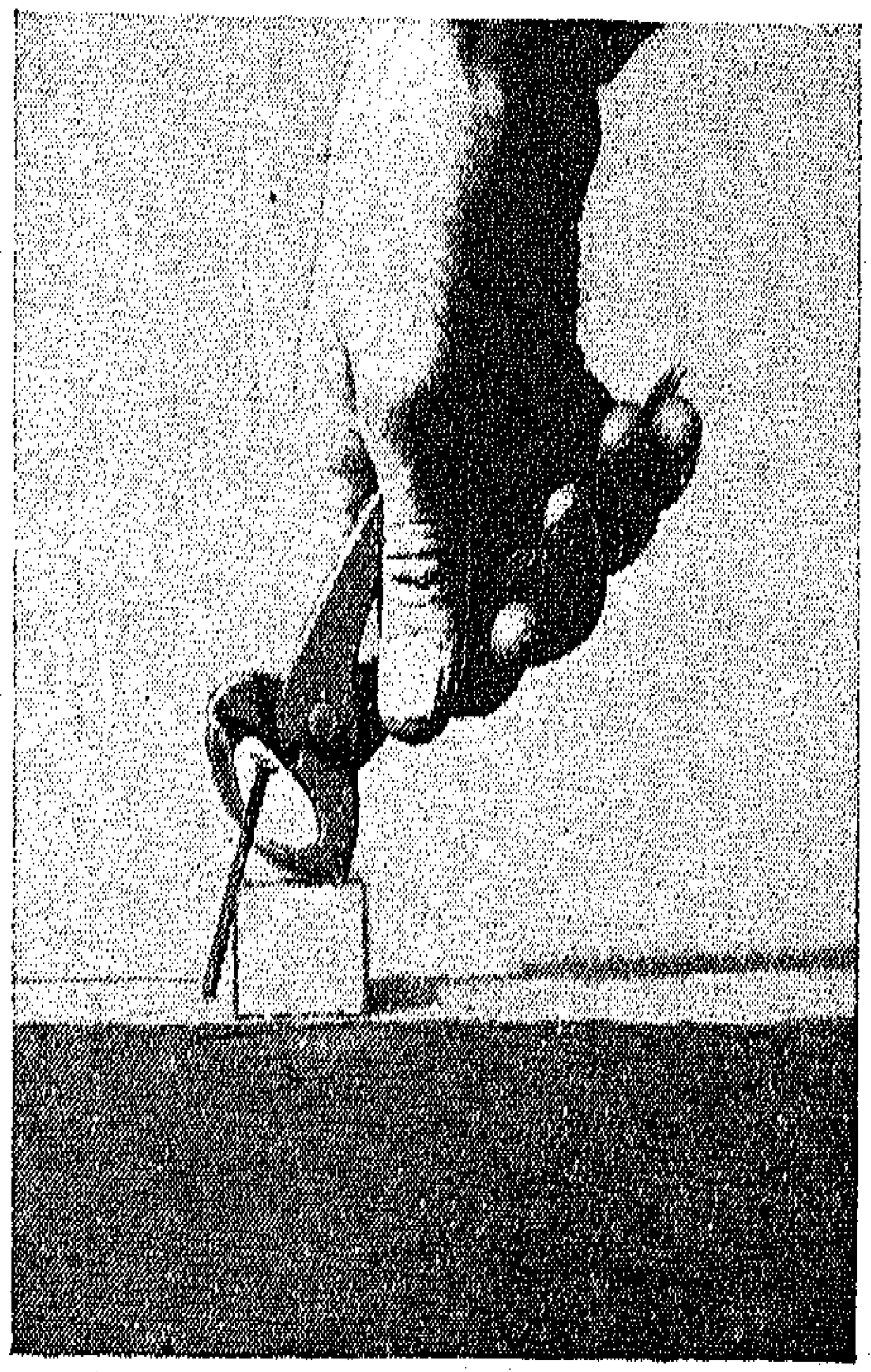


Fig. 11

The raised head (C) is a sort of "half-way house" between the countersunk and the round head.

Wood-screws may be obtained in sizes ranging from $\frac{1}{4}$ in. in length, as used by the cabinet-maker for fixing small hinges, etc., up to 9 in. The diameters of screws are known by their gauge numbers; the thicker the screw the higher the gauge number. Thus a 1 in. No. 8 screw is thicker than a No. 6.

When fastening two pieces of wood together, as in Fig. 13, a clearing hole—that is, a hole a trifle larger than the plain part of the screw—should first be drilled in the top piece, and if the screw to be driven is small, it may be screwed direct into the piece to be joined.

In the event of a large screw being used, however, the piece to be joined should also be drilled with a drill a shade under the diameter of the screw at the bottom or base of the thread.

As the top of countersunk-headed screws are intended to lie flush with the surface of the work, the screw-hole should be countersunk to correspond. This is usually done with a special tool called a countersink bit, used with a hand brace. In some instances it may be found impracticable to use a countersink bit, in which case the depression may be scooped out with a gouge.

Screws, like nails, do not hold so well when used in the end grain of wood, so a thicker and longer screw than that normally employed in cross grain should always be employed.

In driving in a screw, use a screwdriver with a blade a trifle wider than the slot at the start and finish with one of equal width. This method will prevent damage to the slot and also obviate tearing the wood round the screw-head.

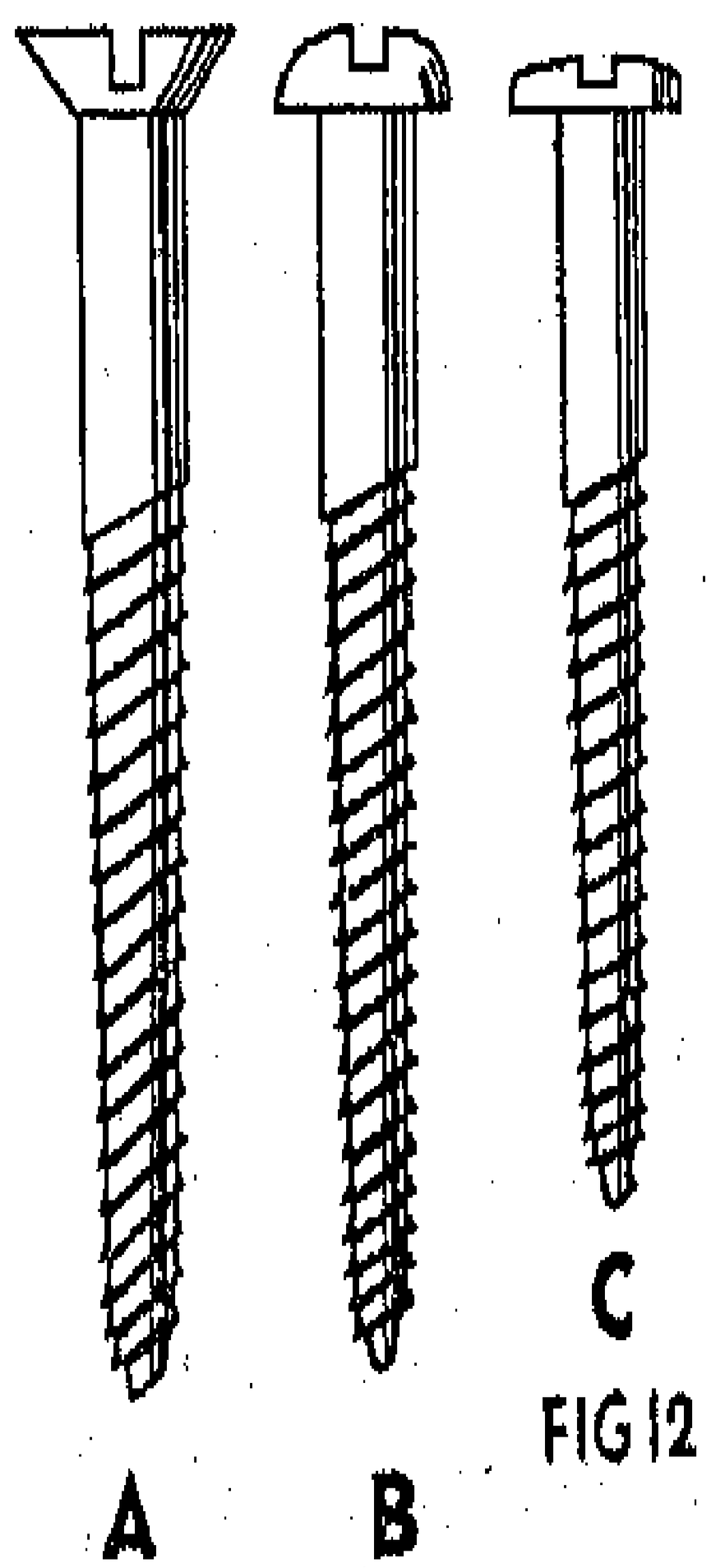


FIG 12

A small quantity of grease smeared on a screw will not only make it easier to drive but will also prevent it from rusting and enable it to be extracted easily at some future time.

Brass screws should always be used in oak as the tannic acid present in this wood has a detrimental effect on iron.

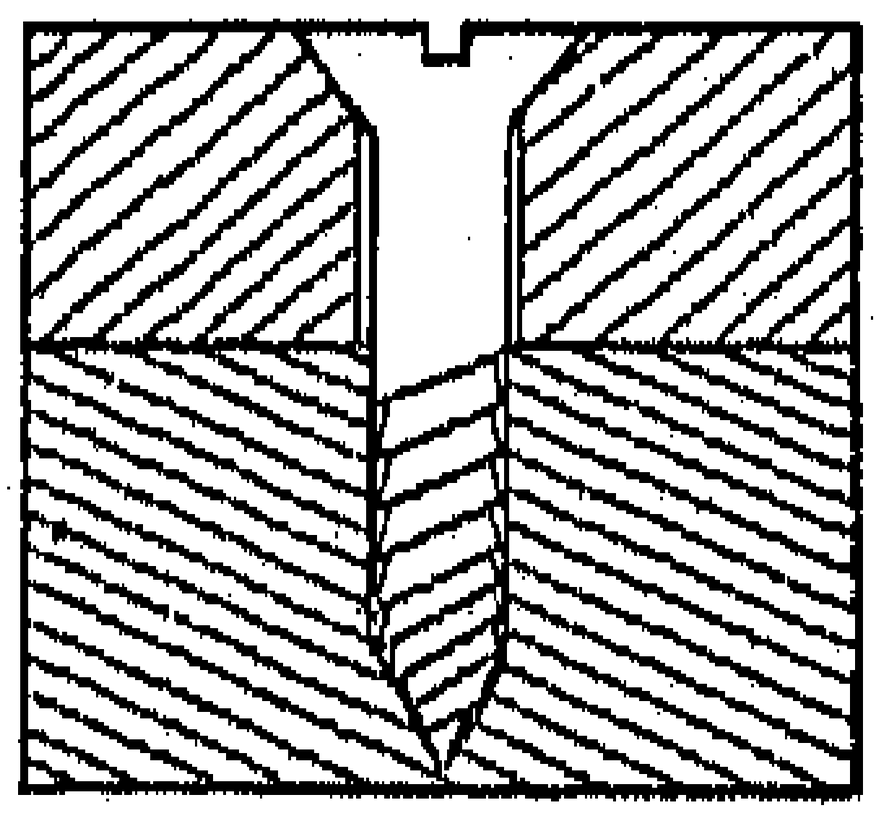


FIG 13

When a small screw has to be driven in such an awkward place as to prevent holding the screw in the normal way, the difficulty may usually be overcome by pushing the screw through a piece of folded paper and using it as a "handle." When the screw is nearly home the paper can be torn away and the screw finally tightened up. For larger screws a thin, narrow strip of tin or brass, with a slot cut in one end so that it can be easily withdrawn, answers the same purpose.

To Remove Screws always use as large a screw-driver as possible to obtain sufficient leverage. In the case of an obstinate screw, try tapping the end of the driver with a mallet at the same time as the driver is being turned. If this is ineffective, hold the end of a hot poker on the head of the screw. This causes the screw to expand slightly, forcing the wood out with it. When cool it contracts and so is loosened.

Coach-screws are invaluable to the woodworker as a substitute for ordinary large screws in positions where the appearance of the heads is immaterial. Holes are first prepared as in the case of the ordinary screw, a metal washer placed on the shank, and the screw is screwed into the wood by means of a spanner or wrench.

CHISELLING

The three common types of chisels used by the craftsman are shown at A, B and C in Fig. 1.

That represented at A is a firmer-chisel, which is possibly the most used tool and

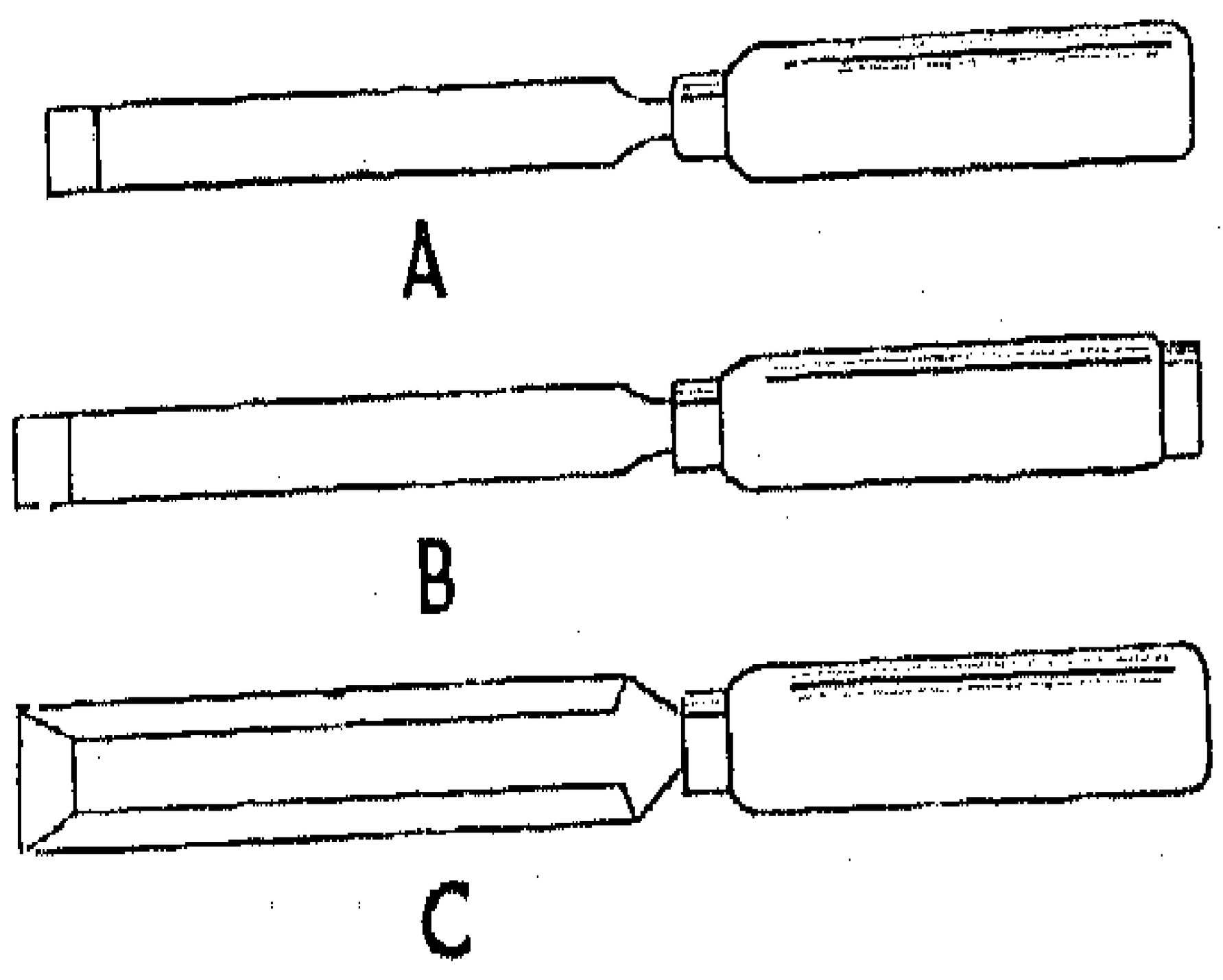


Fig. 1

may therefore be termed the handyman's chisel, as it can be used for cutting mortices in small stuff, paring, etc. The tool shown at B is a mortice-chisel and, as its name implies, is used for cutting mortices. It is more robust than the firmer, and is generally used on large work where it has to withstand the blows from a mallet. The paring-chisel (illustrated at C) is a more delicate tool and has a thinner blade than either of the two tools previously mentioned. It is used principally for finishing off work by hand, and is not struck with a mallet.

The Blade of a chisel is made of cast steel, one end of which is bevelled off to form a cutting edge, while the other end terminates in a shouldered tang which is driven into the handle. As the majority of chisels have to be struck with a mallet, a metal ferrule encircles the tang end of the handle to prevent it splitting, and in the case of the morticing tool an additional ferrule is generally fitted round the top.

For a start, the amateur craftsman should provide himself with a set of chisels comprising ¼, ½, ¾ and 1 in. of the firmer type, as these will be found suitable for most purposes. The set can then be added to as circumstances demand.

Before a newly-purchased chisel can be used it must be sharpened on an oilstone, as the cutting edges of a new tool are only roughly finished on a grindstone, and therefore unsuitable for good work.

A sharp chisel is essential; a blunt one merely breaks the fibres of the wood instead of cutting them. From this it follows that when chiselling has to be done it is a good plan to keep an oilstone close at hand so that the cutting-edge may be touched up from time to time.

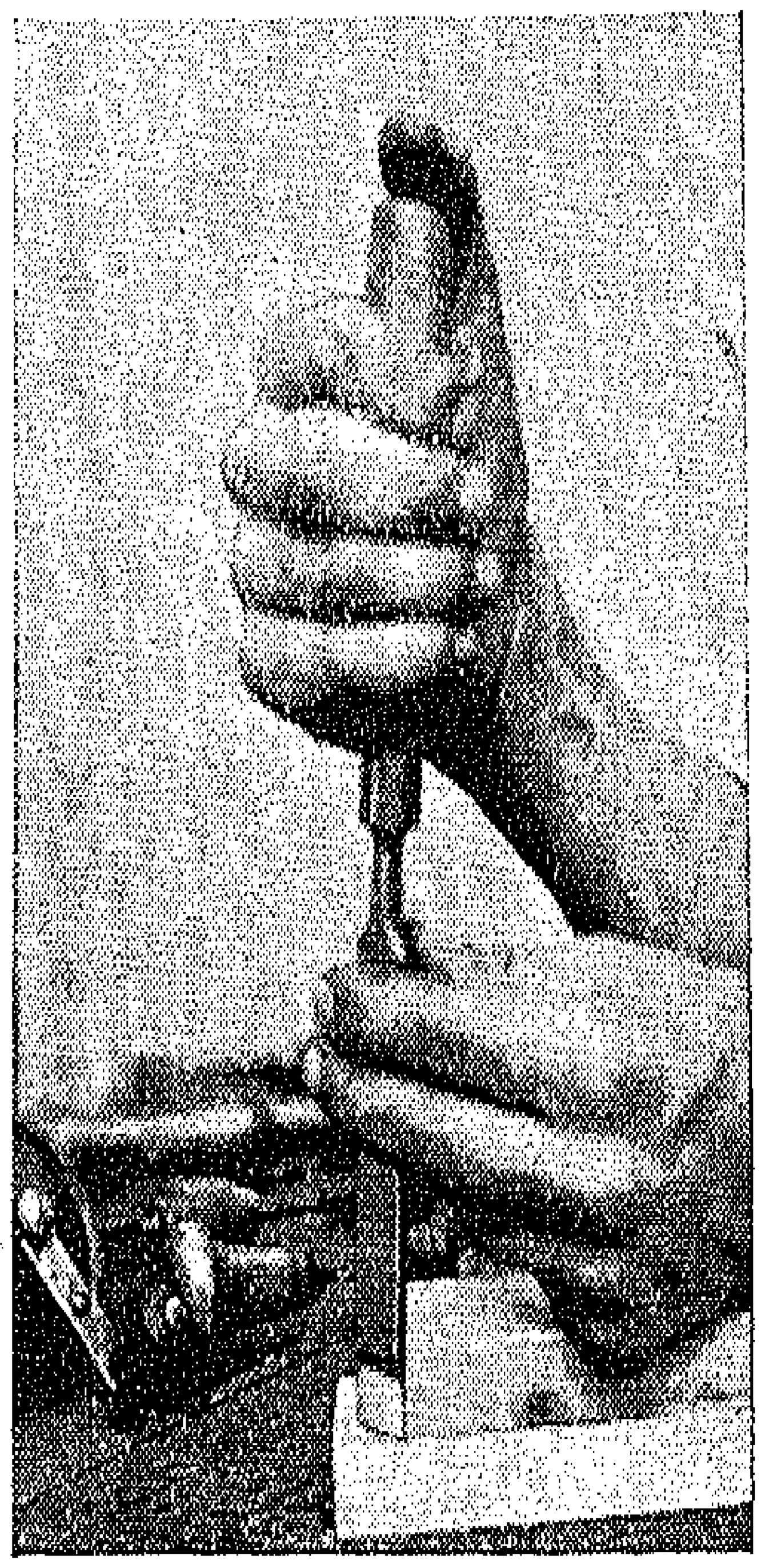


Fig. 2

Fig. 2 shows how a chisel should be held when cutting away a corner of a piece of wood. To do this, first place the wood to be prepared on a piece of flat waste wood—preferably hardwood—to prevent damage to the bench-top, and also to prevent splitting the grain on the underside of the work. Grip the handle of the tool with the right hand, keeping the thumb at the top. Press the left on the work to keep it from slipping and place the forefinger in front of the blade to act as a guide. Now force the tool downwards to remove the waste by making a series of sliding cuts as with a knife, slicing off only a small quantity at a time. A slicing action of the blade makes a cleaner cut than a cut taken straight down. If the work cannot be conveniently held down with the hand, use a cramp.

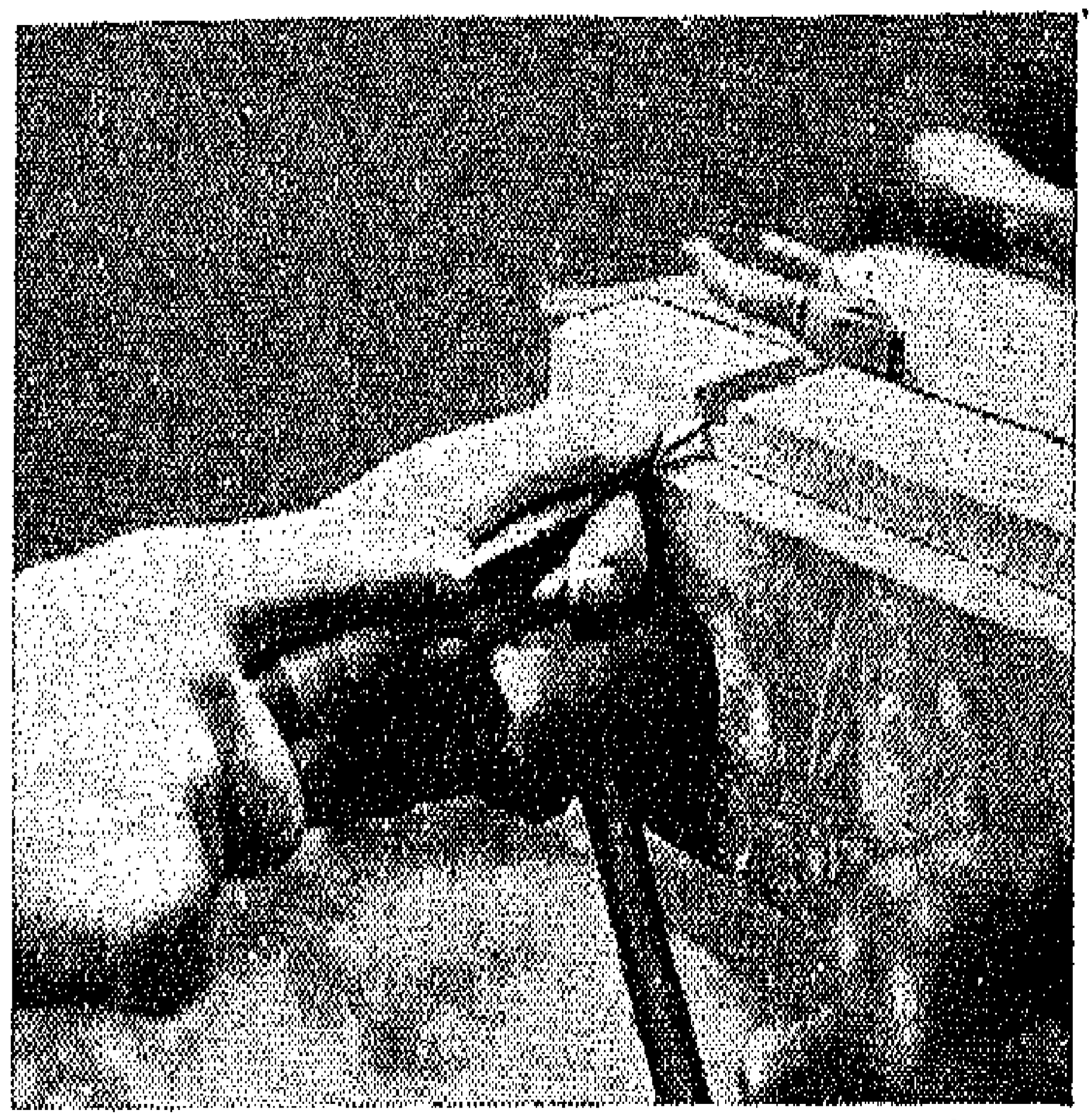


Fig. 3

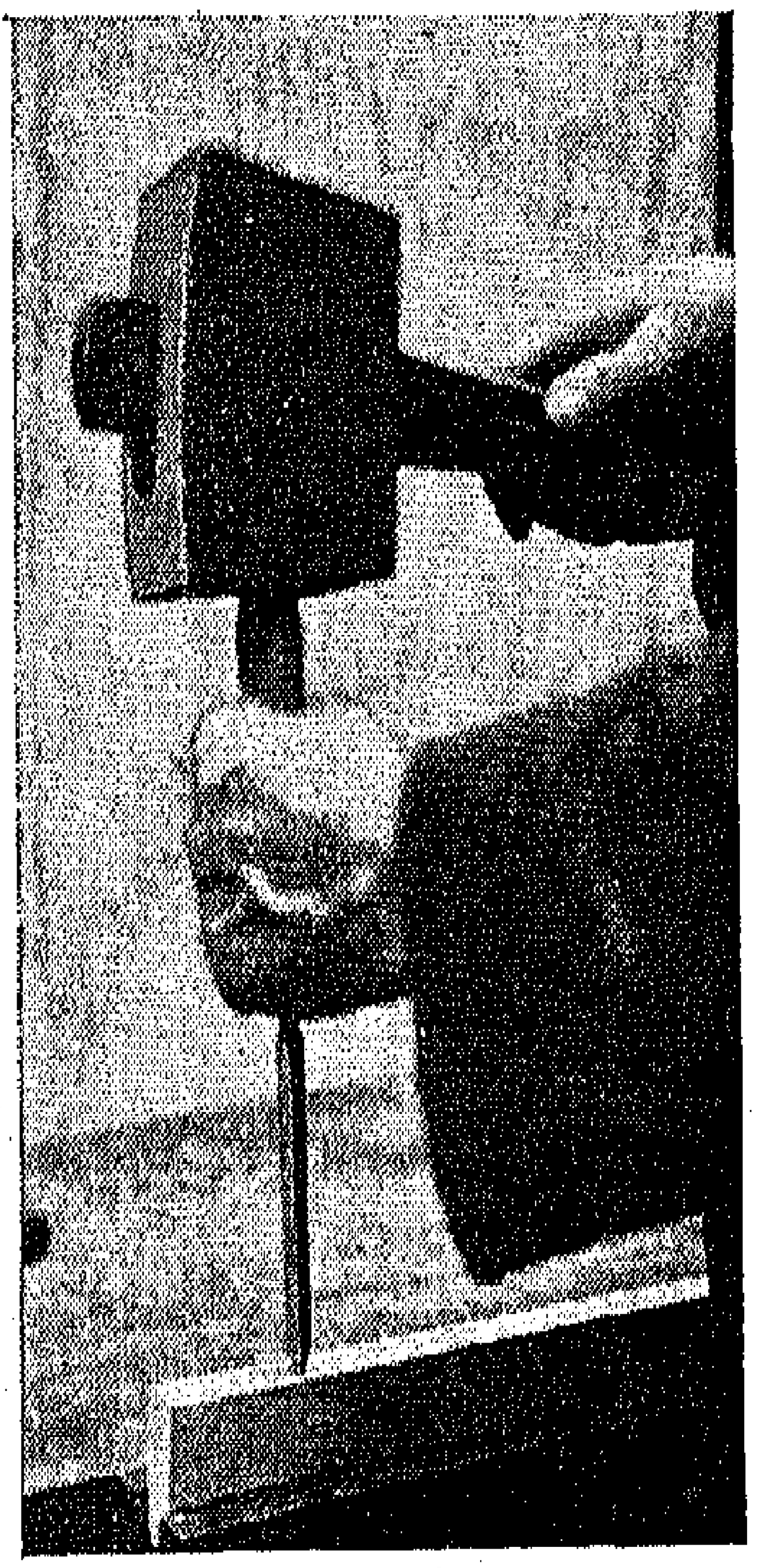


Fig. 4

It may be mentioned here that the greatest care should be exercised when using chisels to keep the hand holding the work as far away as possible from the cutting-edge, as there is every chance of the chisel slipping.

Fig. 3 shows the correct way to hold a chisel when removing the waste from a slot in a piece of work after having been cut down at the sides with a tenon-saw. The work is placed securely in the vice or cramped down to the bench-top, as near the front as possible, and the tool worked from one side of the wood to the middle, reversed, and worked from the other side towards the centre. This eliminates the risk of breaking off the edge of the far side if the cut is made straight through. When

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using the chisel, take a small sloping cut upwards and finish by holding the tool flat on the bottom and working it with a sliding movement, taking care to remove only a small shaving at a time.

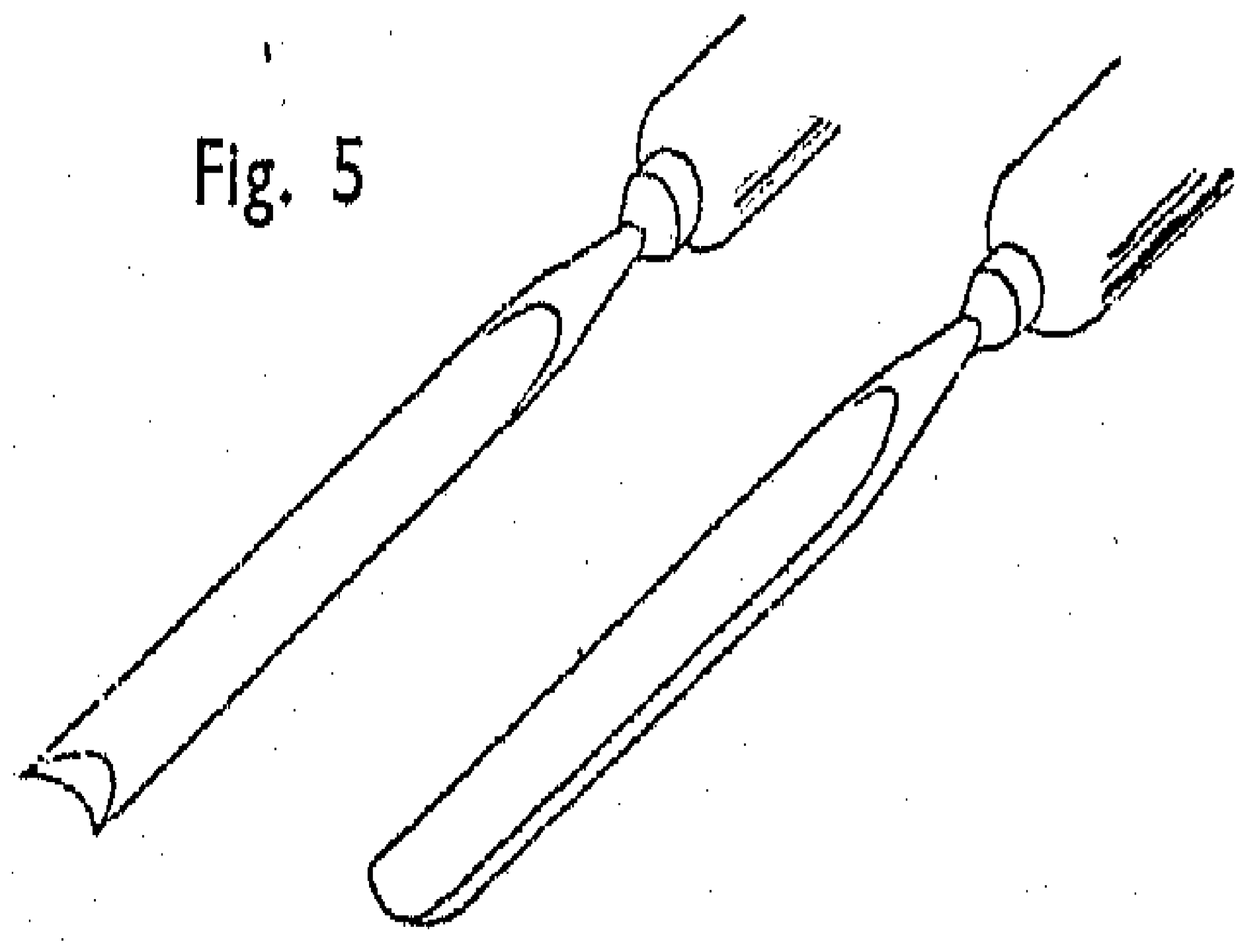


Fig. 5

The correct tool for cutting mortices is the mortice-chisel, although a firmer-chisel can be used on small work. The thick blade of the mortice tool is designed to keep the tool true to its work, so that when the mortice is finished the four sides are square with the face. The width of the blade should be the same as that of the mortice.

Fig. 4 shows the tool being used. After the mortice has been marked out on the top and bottom faces of the work it should be firmly fixed down on the bench, preferably over a leg, as this position is more solid, and therefore better able to withstand the shocks from the mallet. To cut the mortice, start at the centre and work backwards towards the marked line at the end of the hole. Take care to keep the chisel perfectly upright and drive the blade into the wood by striking it smartly with a mallet. *Never* use a hammer, otherwise the handle of the tool will be damaged, and avoid cutting too deeply, as the blade is likely to stick. Repeat the operation by making a series of small cuts until near the mortice line. Take care not to cut right up to the line, as the chisel tends to undercut. Next, start again from the middle and work towards the other end. Continue the process until a hole is formed half-way through the wood. The remainder of the work is done from the other side, so it must be turned completely over. Before fixing it down to the bench, raise the work up on two pieces of wood of equal thickness. The pieces should be so placed as to form a gap under the mortice. By doing this the waste is allowed to fall through the hole on to the bench.

The method of removing the whole of the waste with a chisel, as explained above, is somewhat slow and tedious, and is rapidly becoming obsolete. Its place is being taken by the simple and more expeditious process of first removing as much surplus wood as possible by boring holes with a brace and twist-bit, and finishing the work with a firmer- or a paring-chisel.

A chisel is useful for marking out work and is, in the majority of cases, superior to a lead pencil. When marking out with a square, make sure that the stock is held tightly against the edge of the work and hold the chisel with its bevelled side against the metal blade of the square, away from the operator and also away from the square. The marking is, of course, made towards the worker.

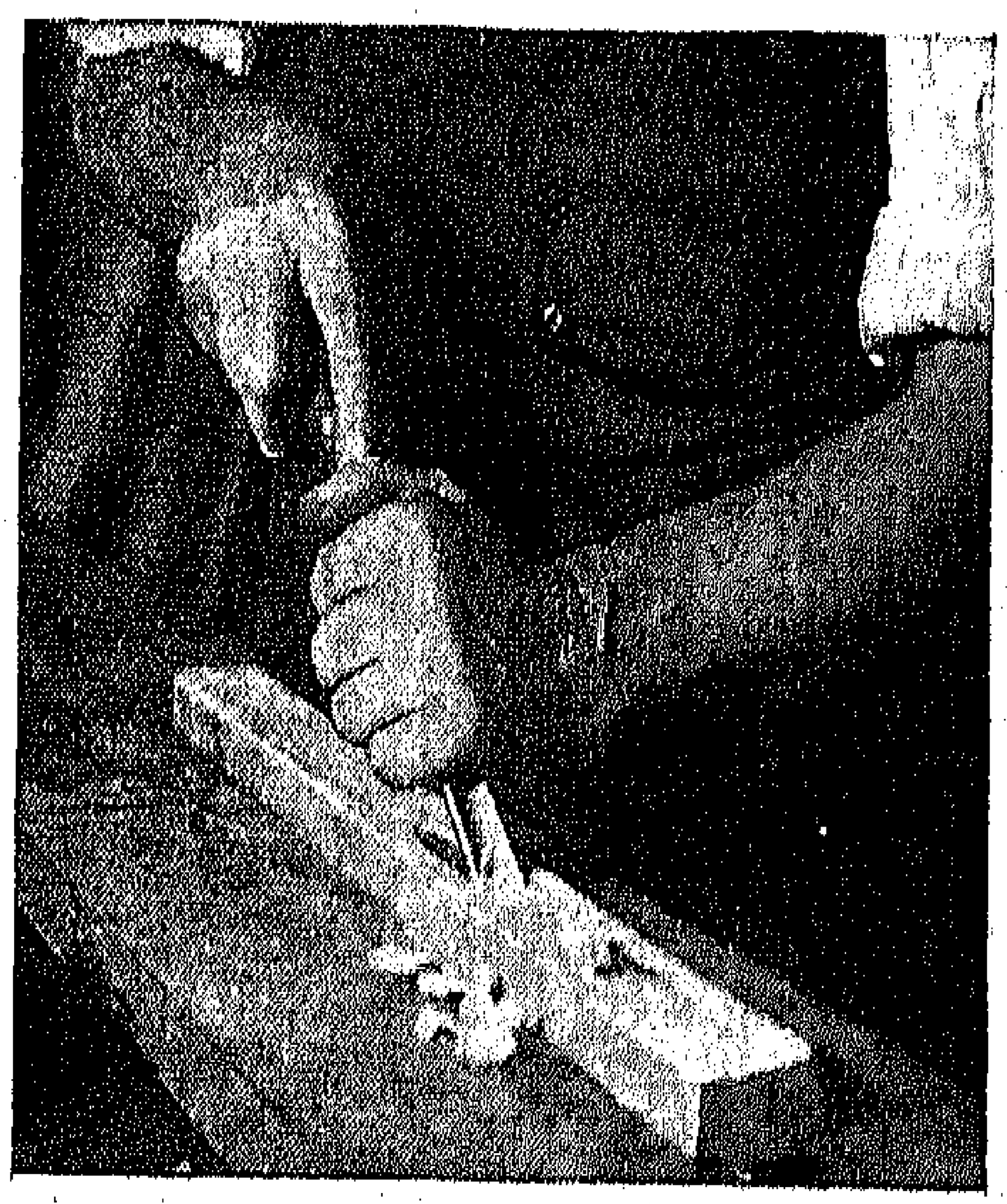


Fig. 6

The Gouge is really a chisel with a circular cutting-edge. Two kinds of gouges are in vogue, namely, the "internal ground," having a bevelled cutting-edge on the concave surface of the blade, and the "external ground," having the bevel on the outside. The two types are represented in Fig. 5.

Gouges are used much in the same way as chisels.

Fig. 6 shows how a gouge is held in forming a channel along a piece of wood.

It is hardly necessary to say that when using chisels and gouges on the long grain of wood the cut is made in the direction of the fibres, as in using a plane.

If you have the misfortune to split a chisel handle there is no need to discard the whole tool, as new handles can be purchased for a few pence.

To Fit a New Handle, first fix the handle ferrule end upwards in the vice, and carefully drill a hole sufficiently deep and a trifle smaller in diameter than the [illegible] After having removed the tool from the vice, insert the blade [illegible] slip the handle over the tang, and give it a few smart blows with the mallet, until the shoulder on the tang prevents further movement. When drilling the hole, take particular care to keep the drill straight, otherwise the blade will not be parallel with the handle.

As the cutting-edges of chisels and gouges are easily damaged if allowed to come into violent contact with other metal tools, it is a wise plan to keep them wrapped up in a piece of baize, when not in use, or to make a proper rack for their reception.

Always keep them in a dry place, and if they are to be stored for a considerable time, smear them with vaseline.

BORING

THERE are very few jobs in woodwork that do not require the use of a boring tool, but although the actual process of boring a hole in wood is quite simple, the correct tool must be chosen to suit the work. Fig. 1 shows an illustration of the three principal boring tools for general work, namely, the bradawl (A), gimlet (B) and the brace and bit (C).

The Bradawl, or sprig bit as it is sometimes called, is the simplest, handiest and the easiest tool to use for boring purposes, but its employment is restricted to making small holes, such as those for the insertion of nails and very small screws. It consists essentially of a hardwood handle and a steel rod or shank, the lower end of which terminates in a double bevelled cutting-edge. The cutting-edge is purposely made sharp to enable it to cut across the fibres of the wood.

Bradawls, like other tools, can be obtained in several qualities. In the common bradawl the shank is simply held in the handle by the friction between the wedge-shaped tang and the

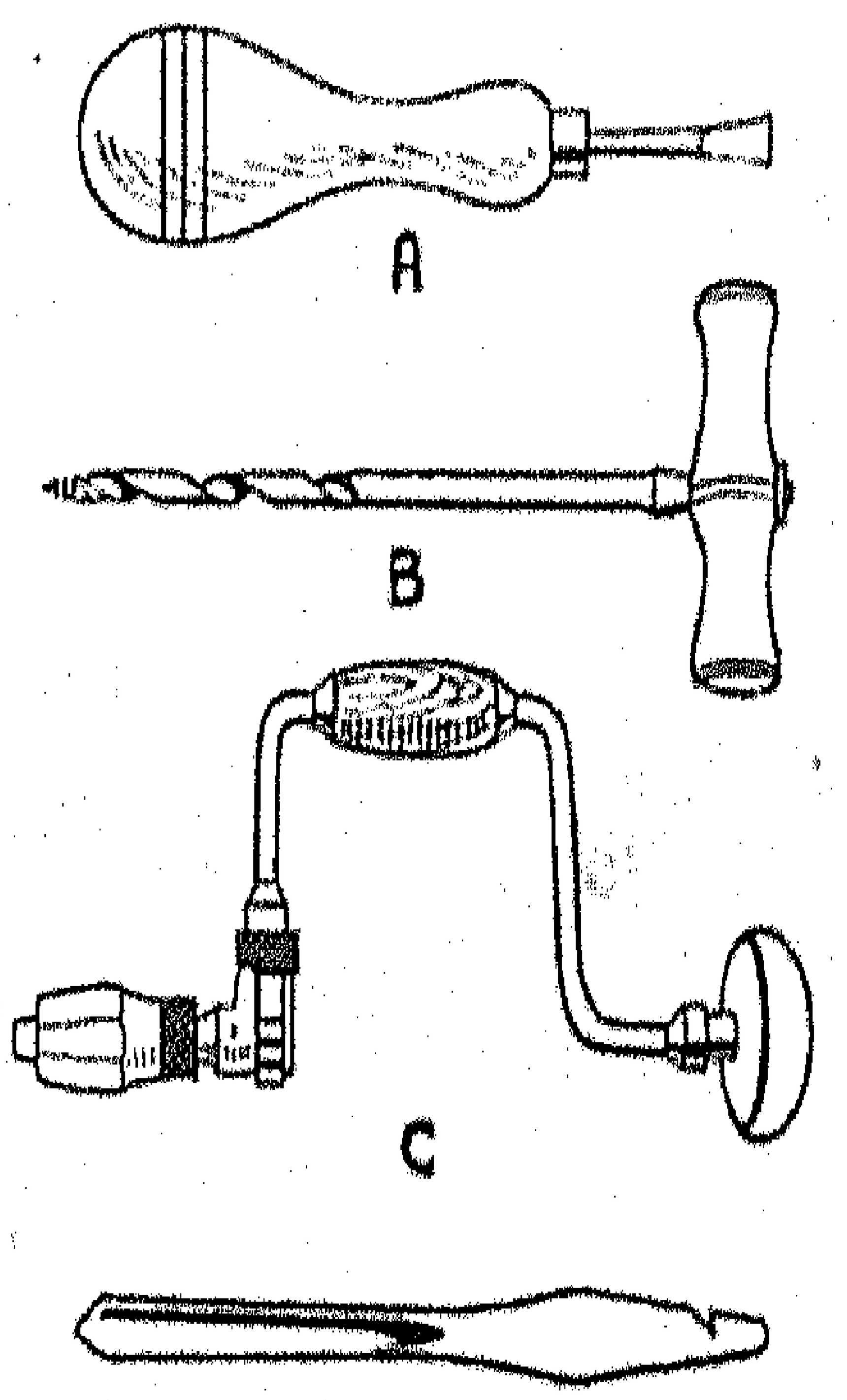


Fig. 1

wood, but in a better tool the shank is further secured by means of a pin driven into the handle and through a hole in the tang. The craftsman should therefore get the latter type unless he does not mind the inconvenience of constantly having the blade part company with the handle.

Fig. 2 shows the correct method of using a bradawl when employed as a hand-operated tool. As mentioned previously, the cutting-edge is used across the grain because if it be used with the direction of the fibres there is a danger that the wood may split, as the wedge-shaped blade forces the fibres apart.

In using the bradawl the blade should be forced lightly into the wood and twisted to and fro and then gradually withdrawn by holding the handle between the first and second fingers of the right hand, pulling upwards and still continuing the twisting movement.

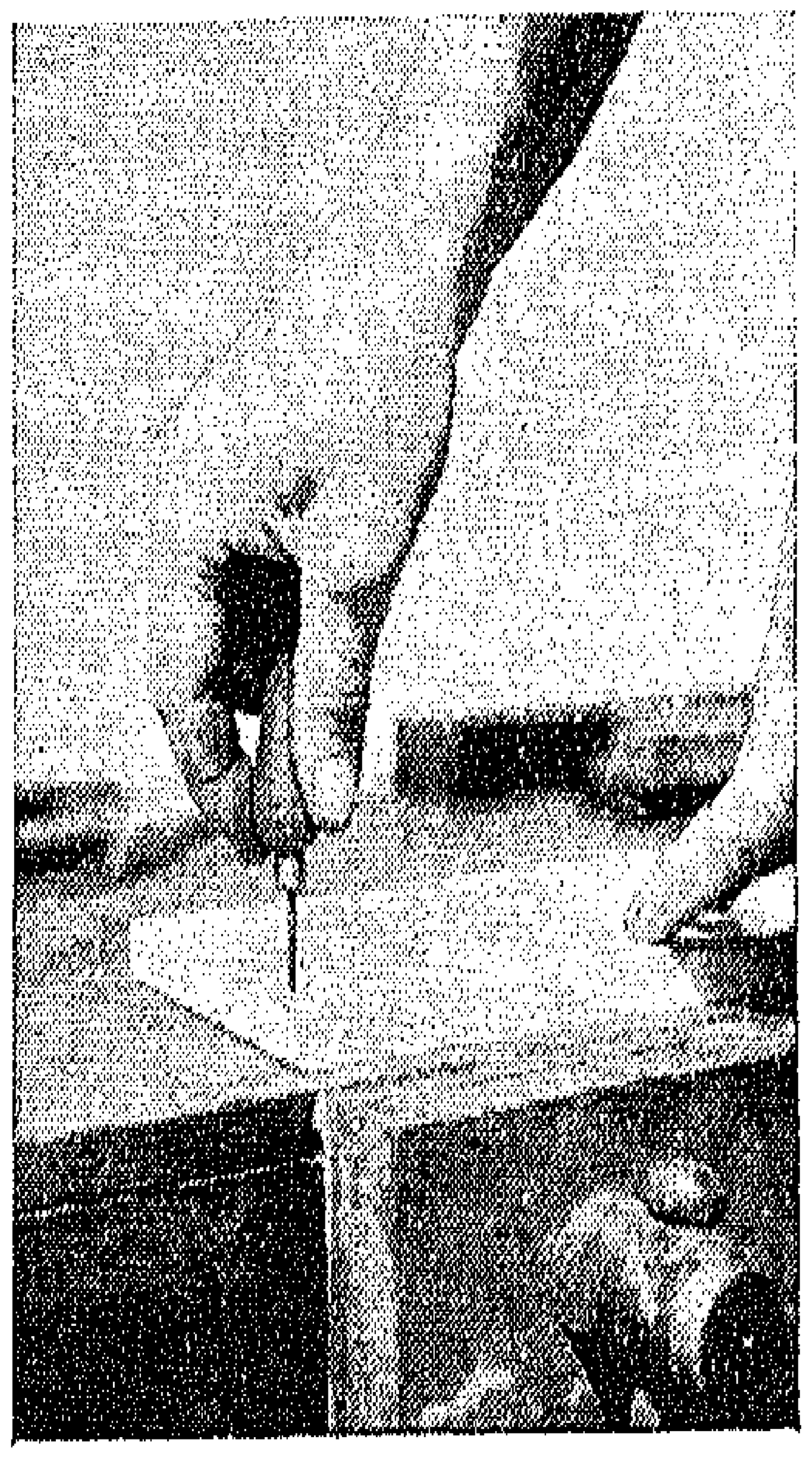


Fig. 2

In some instances it may be necessary to hammer the tool, in which case the top of the handle should only be tapped lightly and the tool twisted as previously mentioned. Great care should be taken not to force the blade to one side when making a hole in hardwood. Failure to take this precaution invariably results in a broken blade and it may also spoil the work, especially if the blade happens to break off short in the wood.

In the event of the blade breaking near the cutting end, do not discard the tool, as it is an easy matter to file or grind the blade to form another bevelled chisel edge. If necessary it can be hammered out slightly so that the edge is a trifle wider than the rest of the shank. As a rule the steel is soft enough to allow of this being done.

Bradawls can now be obtained with a hollow handle containing several different sizes of awls. The blades are held in the stock by means of a wing nut to enable it to be tightened with the fingers. The main objections to such a tool are that it is usually bulky and cannot very well be used with a hammer when one wishes to drive the blade into hardwood, such as oak.

As a bradawl—like every other tool with a round handle—is likely to roll about on the bench and to drop on the floor, it is a good plan to plane or file a flat on two opposite sides of the handle. Before applying a plane, however, make sure that the fixing pin (if fitted) is not likely to come into contact with the cutting edge of the plane-iron.

The Gimlet is a later production than the bradawl for boring holes. It has during its existence taken several forms and it was extensively used when it took on a taper screw-point and screws did not. The early type of gimlet had a groove or hollow with a sharp edge formed along the shank from the screw-point upwards, to rid the hole of chips and to cut the material. This type of tool, however, was not very effective, especially when boring a deep hole. The defect was remedied by forming a twist in the metal stem, as in the case of twist-drills and bits, which are more or less self-clearing.

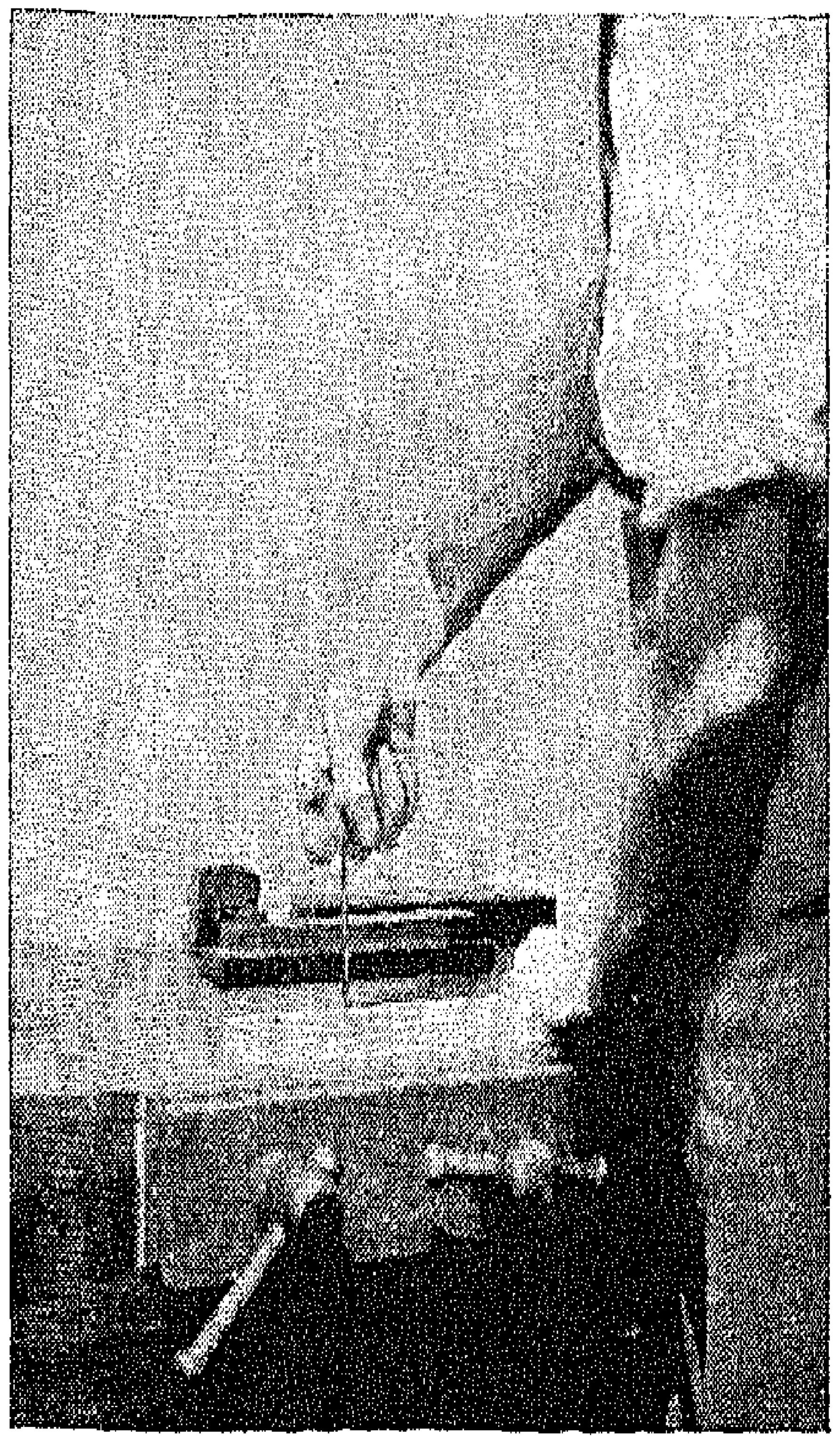


Fig. 3

The screw-point of the gimlet only draws the tool into the wood and any cutting done is produced by the sharp edge of the groove or channel. There are several types and sizes of gimlets, but the one shown at B in Fig. 1 is a common form and will serve for general purposes.

Fig. 3 shows how a gimlet is held in boring wood. The point of the tool is applied to the work at the position required, pressed down and turned in a clockwise direction. When the point has once established itself in the wood it draws itself in and cuts the hole. The operation then consists in merely twisting the handle. The tool is withdrawn by simply pulling the handle, rotating the shank back and forth, as withdrawing a bradawl, to bring out the core or waste.

The main points to be observed when using a gimlet are these: Never use it for boring holes near the end of a piece of wood, as there is great danger of splitting. Always start a hole with the tool held upright, because once the shank is in the wood the fault is difficult to rectify. A gimlet cannot be used successfully when boring into end grain, as the screwed end cannot obtain sufficient grip. Like every other cutting tool the gimlet must be sharp if clean-cut holes are required.

Gimlets appear to be going out of fashion and their place taken by the more efficient hand-drill, mentioned later in this article.

The Brace and Bit may be justly termed the "king" of boring tools and is perhaps the most frequently used. The brace is the tool for holding and rotating the bit. It consists of the head for holding, the crank for revolving the bit and the chuck for holding the bit.

Although the bradawl and gimlet are useful tools within their limits, the brace and bit is a much handier and better tool because a constant, even rotation of the crank, coupled with a better form of boring tool, produces a better job more easily effected. The enormous leverage obtained by the

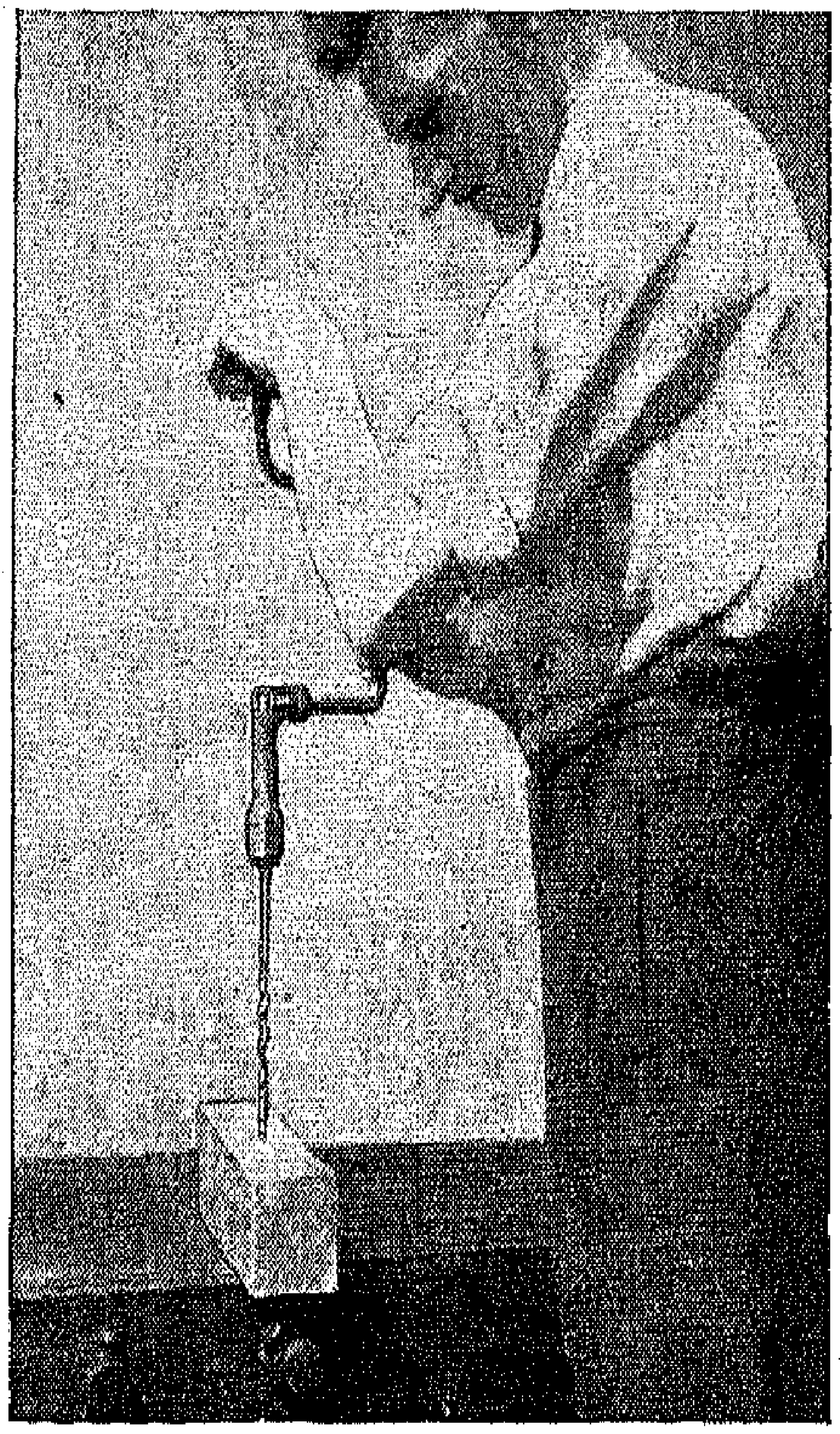


Fig. 4

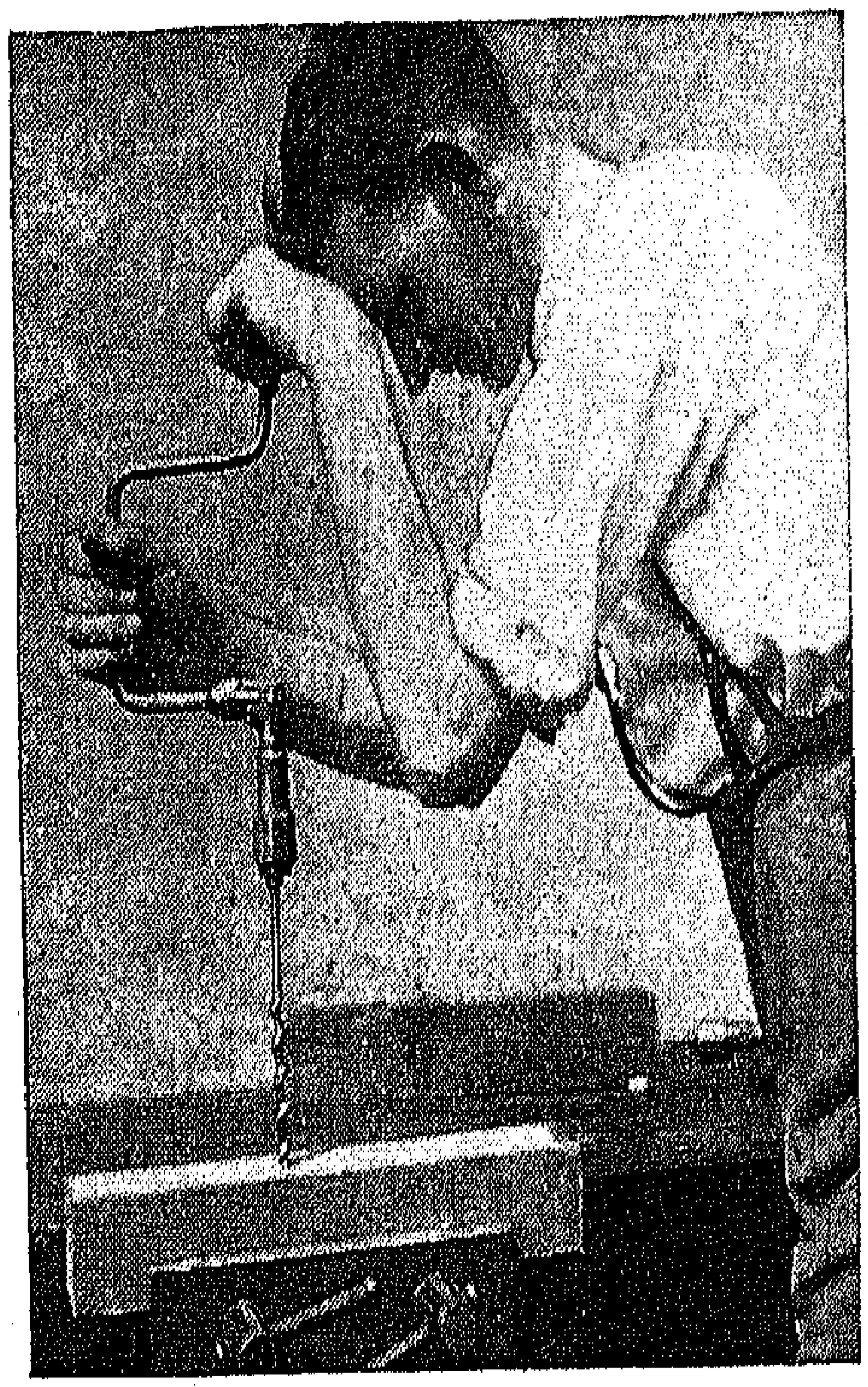


Fig. 5

sweep of the crank enables large, deep holes to be cut with the minimum of effort and the ratchet arrangement now fitted to most braces allows the tool to be used in confined places.

The brace is used in an upright position, as illustrated in Fig. 4, with the left hand placed on the broad top and exerting the necessary pressure while the right hand revolves the crank.

When greater pressure is required on the bit, as when boring large holes, it is generally an advantage to steady the tool by allowing the forehead to rest on the left hand (Fig. 5). If still greater pressure is necessary to operate the bit effectively, the brace may be used horizontally against the operator's chest (Fig. 6).

A common form of boring bit, known as a centre-bit, is shown at A in Fig. 7. Such bits are used for making holes up to about 3 in. in depth and are made in a number of sizes ranging from ¼ in. to 1½ in. It will be seen from the drawing that the centre-bit consists of three main parts. The triangular centre point acts as a guide when boring; the "nicker" or outside cutter cuts a circular groove, while the "router" cuts away the waste wood between.

When using the tool it is advisable to place the work on a piece of waste wood to prevent damage to the bench-top.

Place the centre point of the bit on the wood where the hole is to be and apply an even pressure on the top of the brace with the left hand and turn the crank with the right. Take care to keep the tool upright with the work. This can be tested by observing whether the first cut of the nicker cuts equally all round. Continue boring until the centre point appears on the back face, then turn the work upside down and continue boring from that side. Do not press heavily on the brace when finishing the hole, otherwise the remaining waste will probably break off in the hole and thus necessitate the use of a gouge to clear it out. If the work has been carefully done a straight clean hole will result.

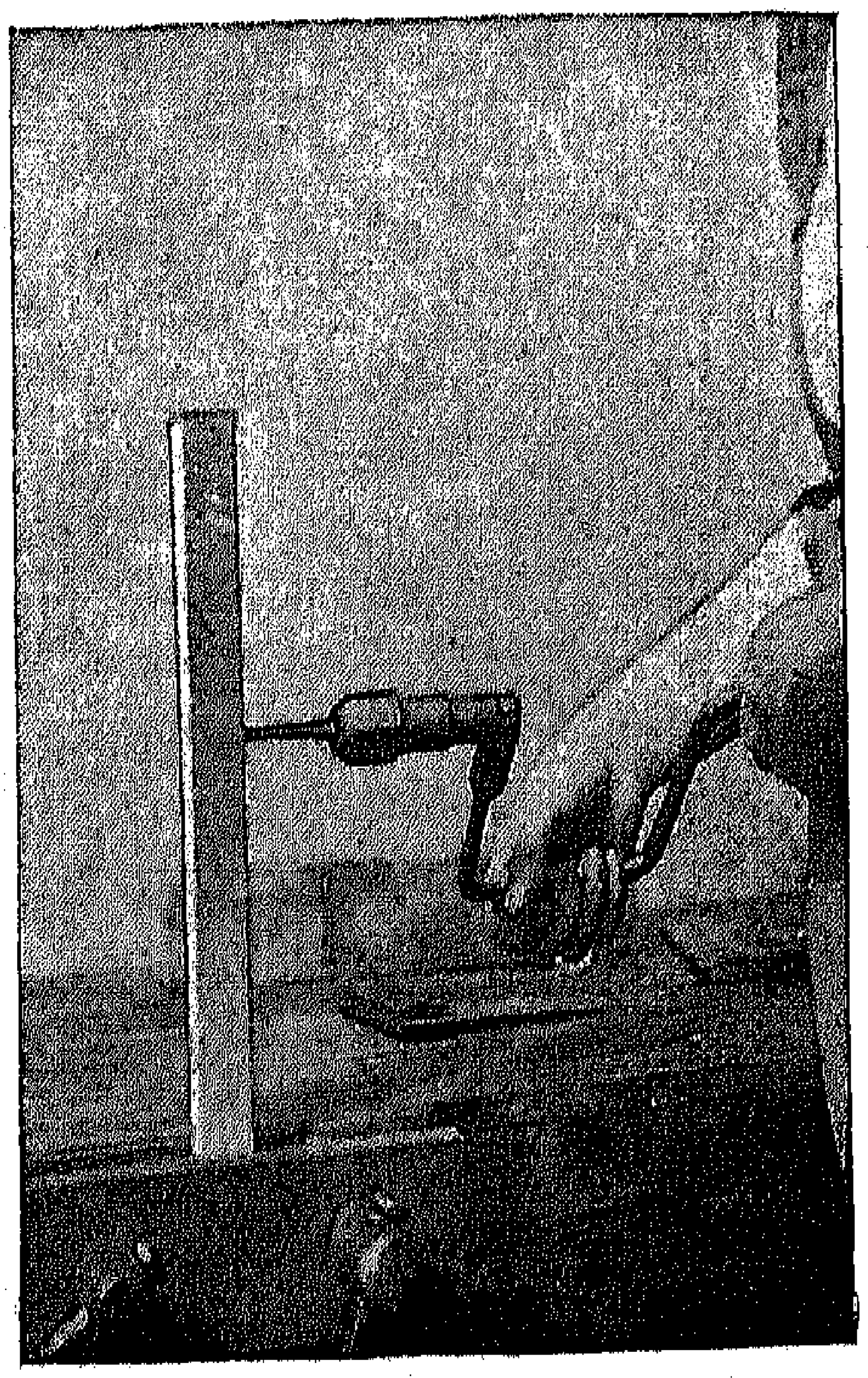


Fig. 6

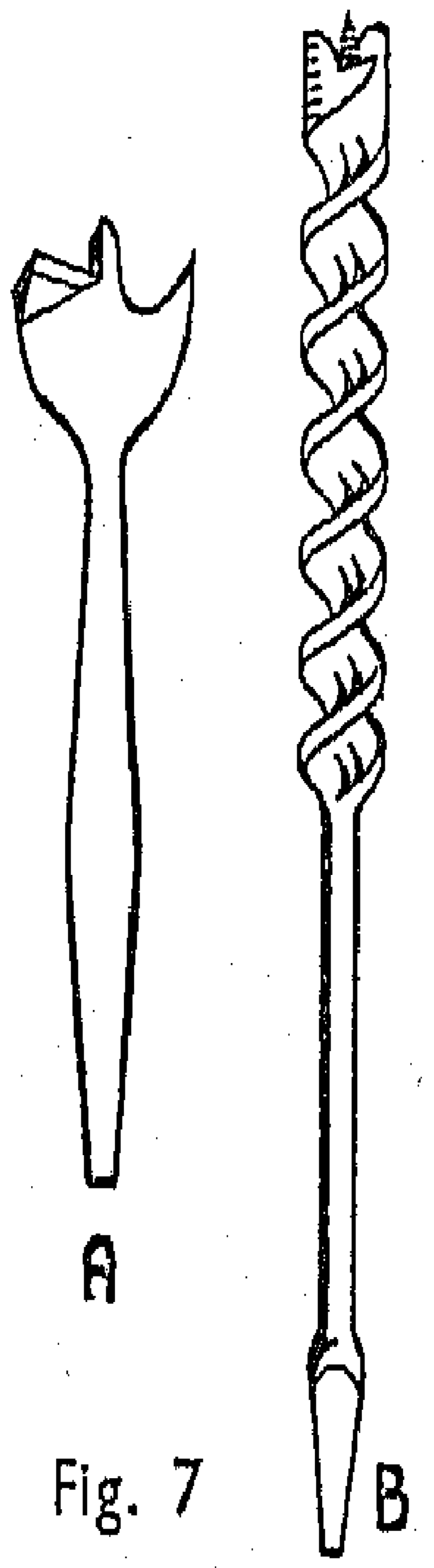


Fig. 7

In ascertaining the size of a centre-bit to cut a certain sized hole, do not measure its extreme width, as the hole produced will be a trifle larger in diameter. The hole produced by a centre-bit is equal to twice the distance between the centre point and the nicker, because the radius of the outside edge of the router is smaller than that of the nicker. This will be readily understood by referring to Fig. 8.

For producing deep straight holes there is nothing to beat a twist-bit, an illustration of which appears at B in Fig. 7. Like the gimlet, the twist-bit is provided with a screw-point which draws the tool into the wood and thus requires little or no pressure when boring holes. The spiral shank also helps in drawing the cutter into the wood and lifts the waste chips to the top of the hole.

Twist-bits.—There are numerous types, all of which work more or less on the combined principle of the gimlet and centre-bit. The chief point to observe when using a twist-bit is to see that the brace is held perpendicularly to the work, as once a small portion of the shank has entered the wood "on the skew" the fault cannot be rectified by leaning the tool over, as such practice would ruin the tool.

To ensure the tool being upright it is a good plan to place a try-square at the side of the work to act as a guide, as indicated in Fig. 9, or better still to get an assistant to tell you when the tool is in the correct position. A little practice will soon enable you to bore holes without such aids.

The general design of a closed-end twist-bit makes it particularly useful for boring holes in the end grain of wood, where the use of a centre-bit would be useless.

It sometimes happens that a number of holes of uniform depth has to be bored, as in dowelling. This necessitates a depth-gauge which may be either bought or home-made. A suitable gauge for a twist-bit would be a piece of sheet tin or brass encircling the shank at the desired distance from the cutting edge and fastened by means of a small bolt and nut. Or the shanks or centre-bits could be marked with a piece of chalk or by sticking on a piece of gummed paper at the desired distance.

There are numerous other kinds of bits used with the brace including such items as spoon-bits, countersinking-bits, screw-driver-bits, etc. Spoon-bits are to be obtained in sizes up to about ⅝ in. in diameter. The countersink-bit is employed for countersinking the tops of screw-holes to allow the screw-head to lie flush with the surface of the work. The screw-driver-bit is useful for driving in large screws where a powerful leverage is required, extracting obstinate screws and driving in a number of screws rapidly.

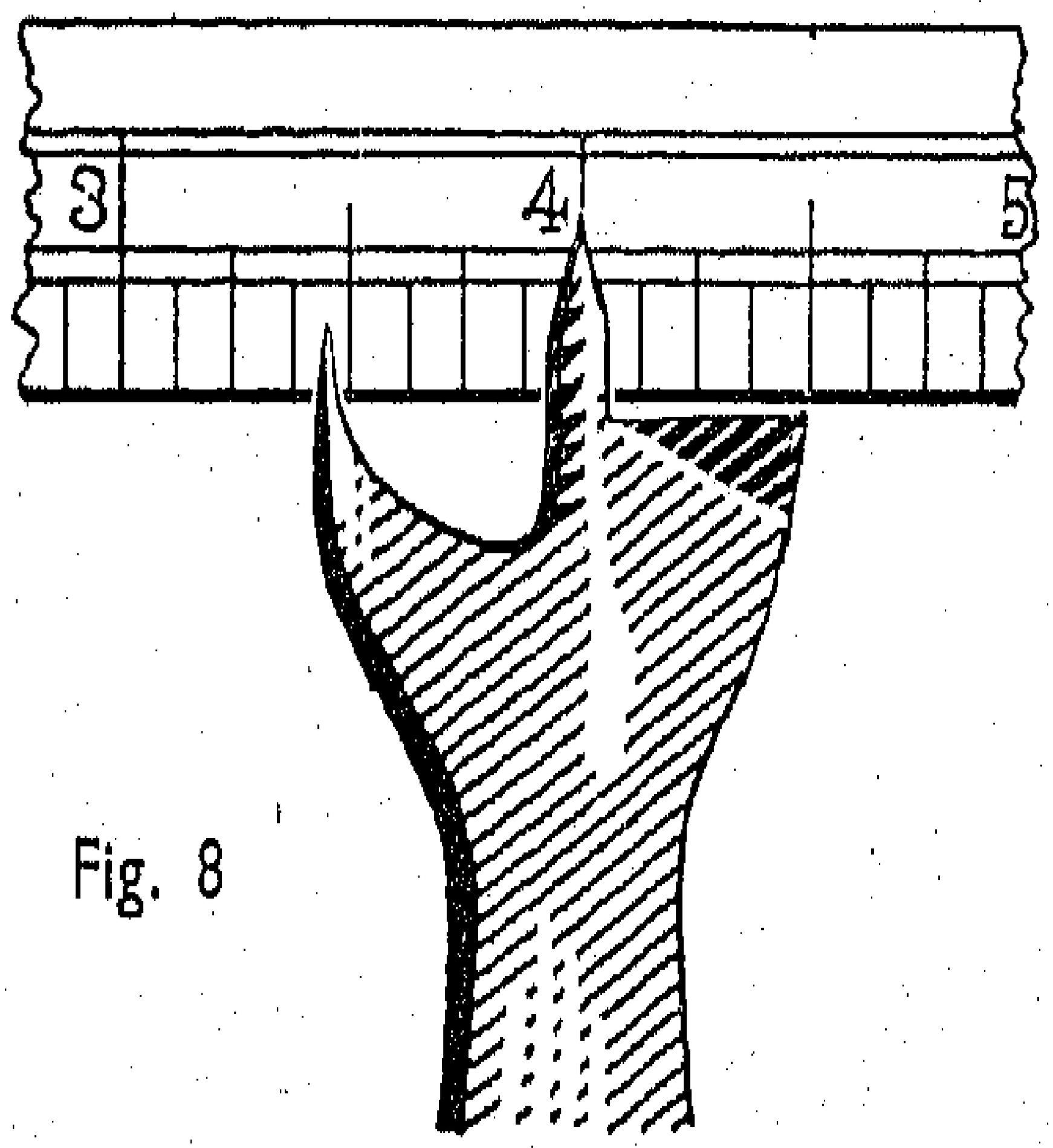


Fig. 8

The hand-drill shown in Fig. 10 is rapidly taking the place of the bradawl and gimlet. The twist-drill—the same

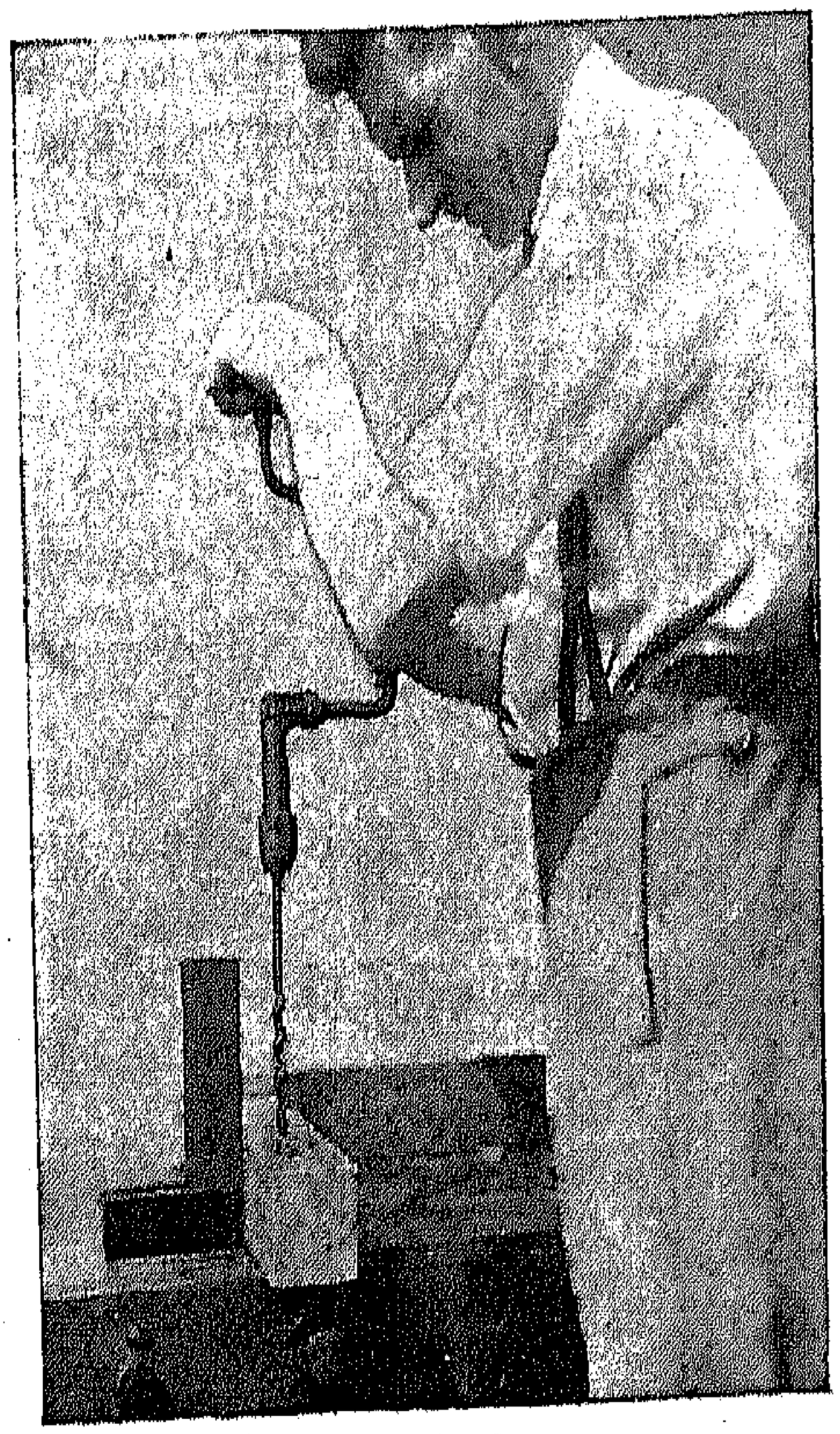


Fig. 9

kind as that used in metal work—is held in a small adjustable chuck and driven at high speed by means of a geared wheel operated by a handle. This enables a clean accurate hole to be cut in the minimum of time and with little risk of splitting the wood even when drilled near the edge. A standard-sized hand-drill usually accommodates drills from $\frac{1}{64}$ in. to $\frac{1}{4}$ in. in diameter.

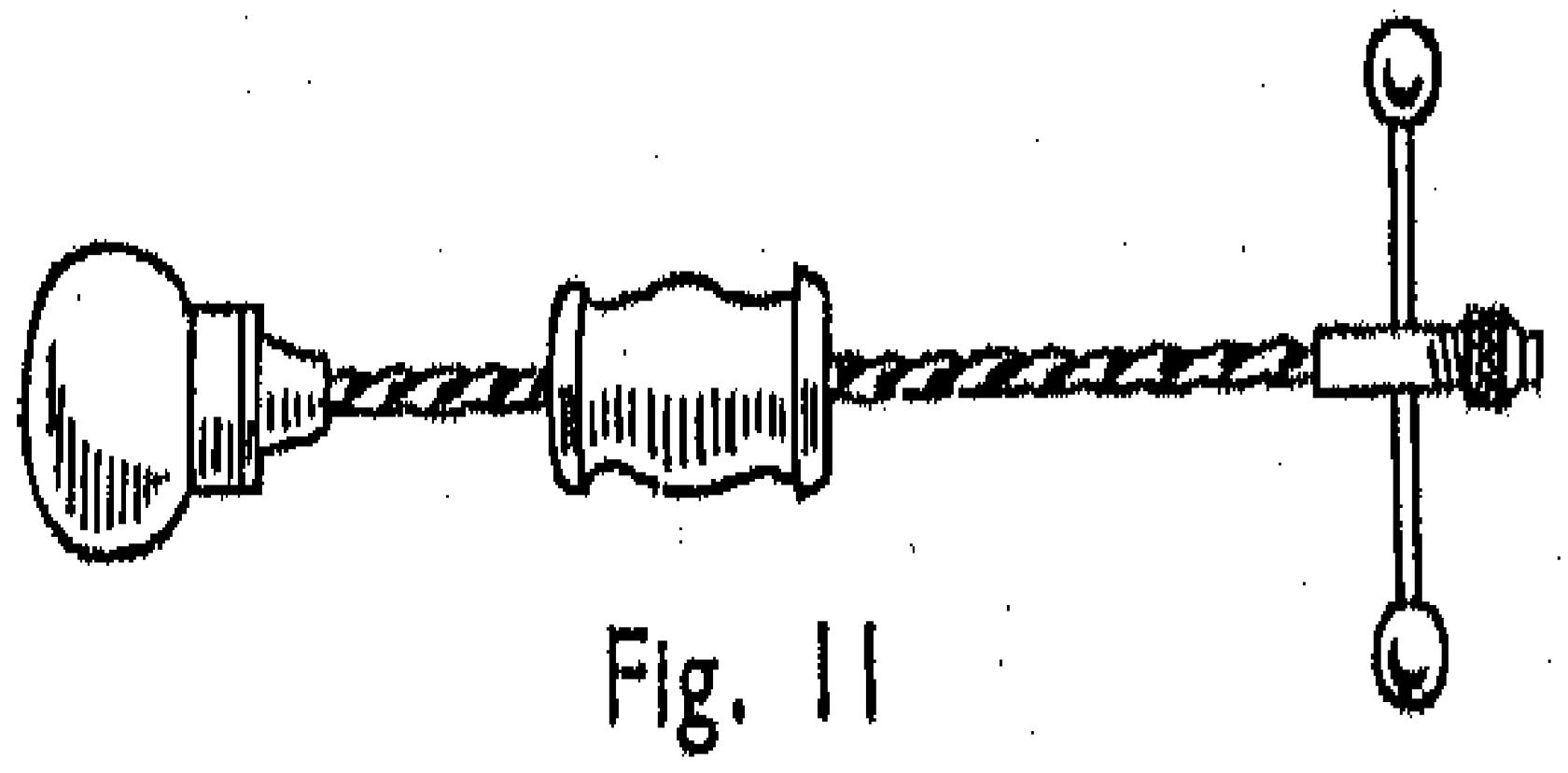


Fig. 11

The Archimedean drill (Fig. 11) is extremely useful for making very small holes.

Motion is imparted to the drill, which is held in a miniature chuck, by working a bobbin up and down a twisted stem which is free to revolve in the top by which the tool is held. In the old type of drill the rotation of the bit is reversed at every up and down stroke but these are being replaced by a tool having a ratchet arrangement which allows the drill to revolve in a clockwise direction only.

The bits used with such a drill are usually spear-pointed and can be purchased in assorted sizes at a few pence per dozen, or, if the user feels disposed, he can make them out of knitting needles. To do this, cut off a piece about 2 in. in length and soften the steel by heating it up to redness and then allowing it to cool slowly in dry ashes. If necessary, file a flat at one end to fit the chuck.

Hammer the other end out more or less flat according to the size of the hole to be drilled and file it to a spear-point, using a fine smooth file for the purpose and taking care to get the cutting edges equal. The cutting edge should be "backed off" by filing the back edge, holding the tool on the slant. This will be reversed, of course, on the other cutting edge. The drill is ready for use when it has been hardened by heating it up to redness and plunging it into some grease to cool it rapidly.

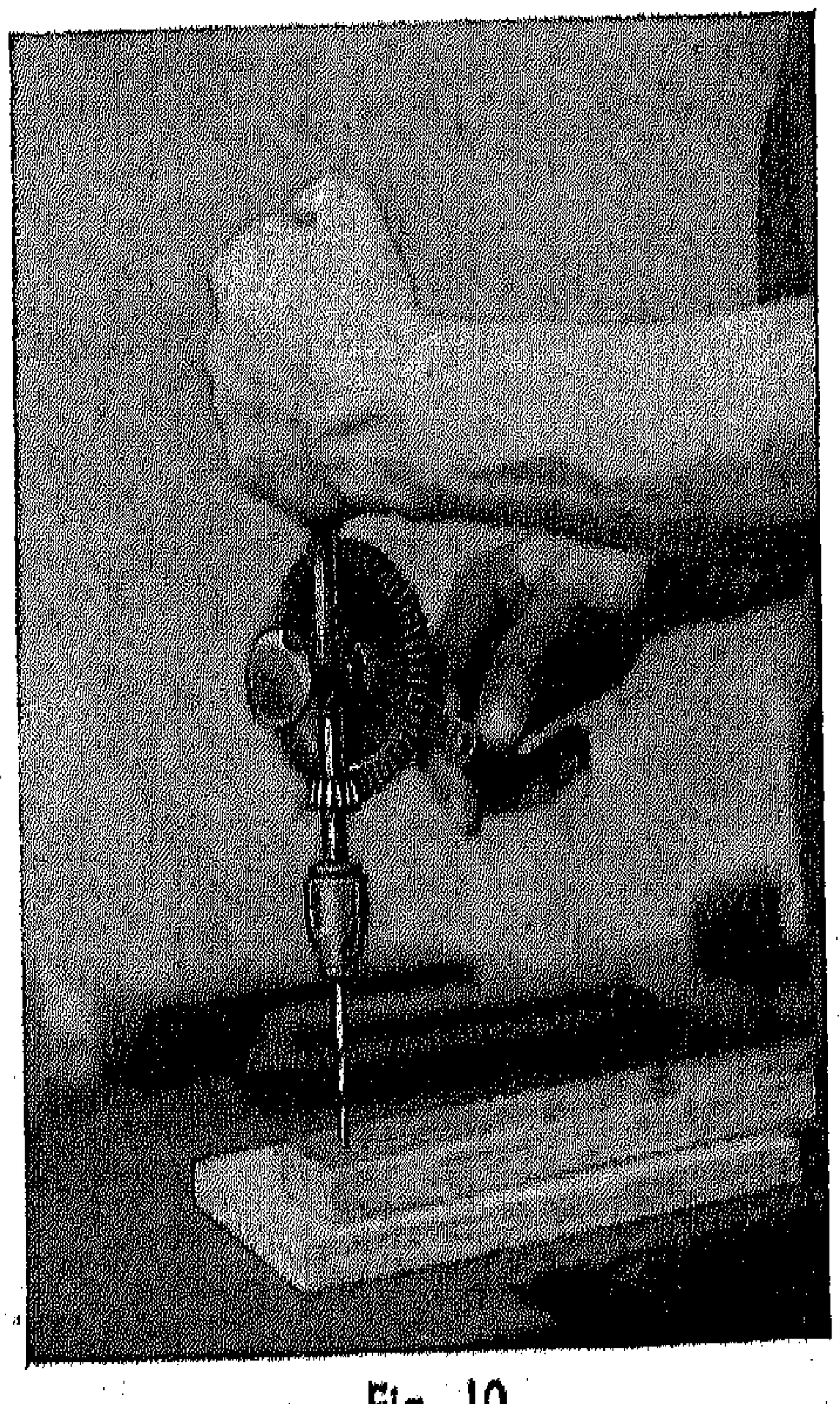


Fig. 10

REBATING

Rebating, or rebetting as it is often called, consists of cutting a rectangular recess along the edge of a piece of wood. It is used as a means of setting glass, panels, etc. in a framework, as shown at A in Fig. 1, and in some cases to form a joint with another piece at right-angles, as illustrated at B.

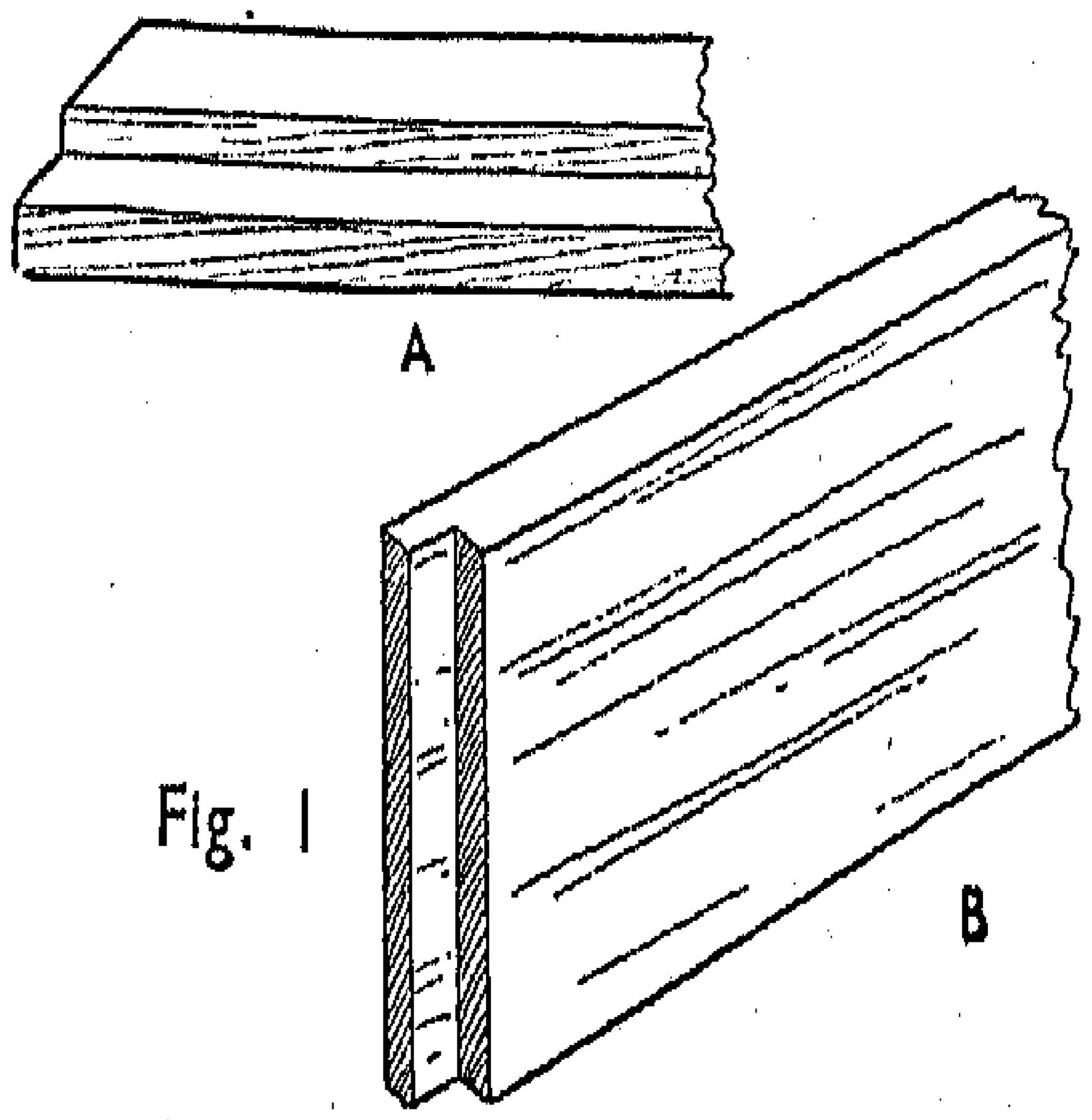


Fig. 1

In the former, the rebate is generally formed on the long edge with the grain of the wood, while the latter is formed transversely to it. The transverse rebate is used largely in the construction of drawers and in cases where a simple yet effective joint is required though the outer faces of the pieces are to remain flush.

As a general rule a rebate is required on a piece of work already prepared, that is, it is already planed and trued up to size.

The first thing to do when making a rebate on the long edge of a piece of timber is to mark it out to the desired width and depth with the aid of a marking-gauge. Adjust the gauge to the proper width and run the stock along the front edge to mark the width on the face, then readjust the gauge to the correct depth, and mark along the edge by running the stock along the face.

The next process consists of removing the waste; there are several methods of doing this. If the recess is shallow, the rebate-plane may be used to advantage, but if it be deep, the plough or, failing this, a chisel, can be employed.

When the rebate-plane is resorted to it is a good plan to fasten a strip of wood along the sole, as shown in Fig. 2, to serve as a guide; the width of the strip being so adjusted as to expose only sufficient width of the cutting-edge of the iron to suit the width of the recess. Do not fix the guide directly to the sole with nails or screws as is so often done, as the marks left by them may damage the most important surface of the plane. A much better plan is first to fix the strip to another piece of wood and then screw it to the side of the tool, as shown clearly in the drawing.

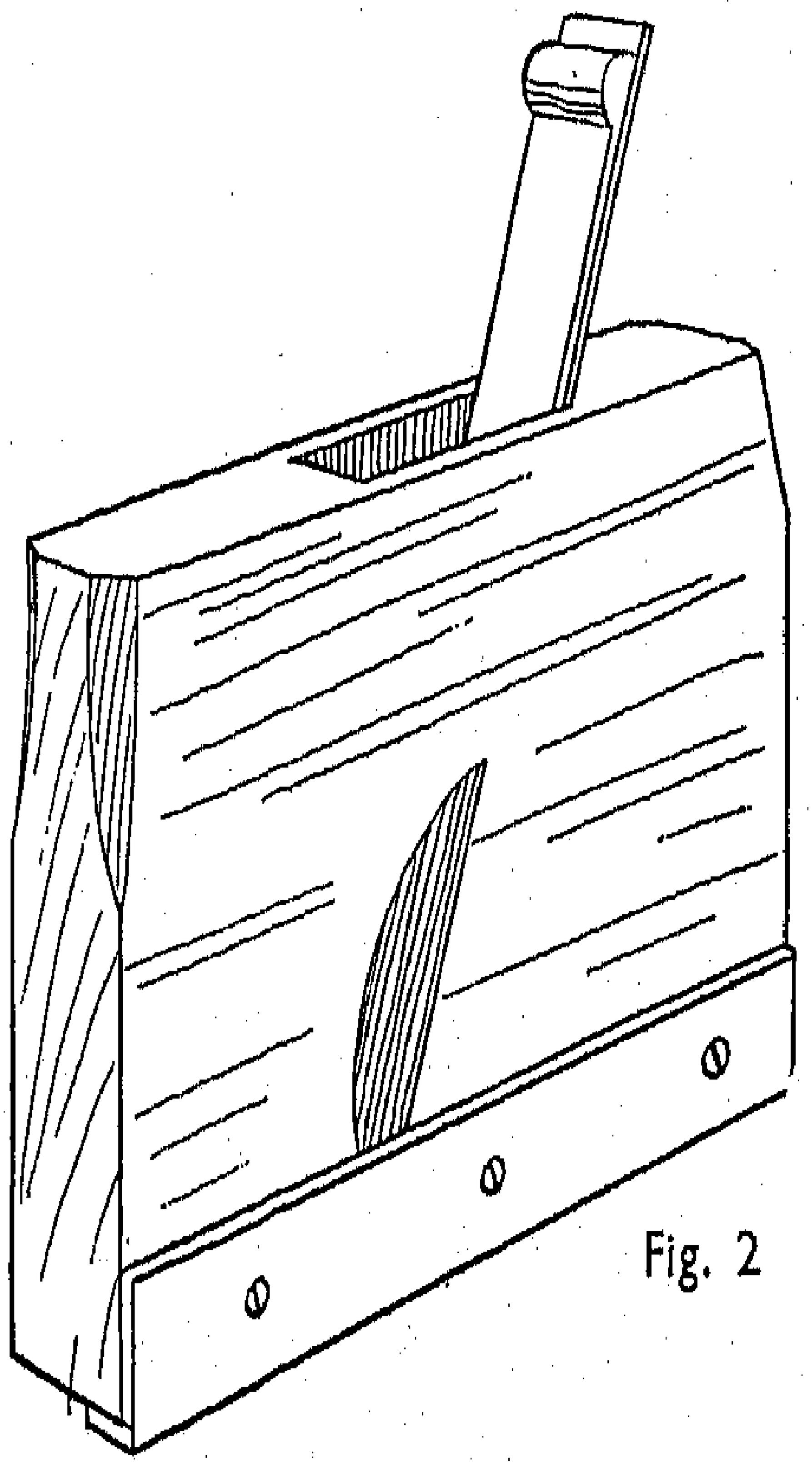


Fig. 2

The rebate-plane is used in the ordinary manner by taking long, even strokes along the edge of the work, taking care to keep the tool square.

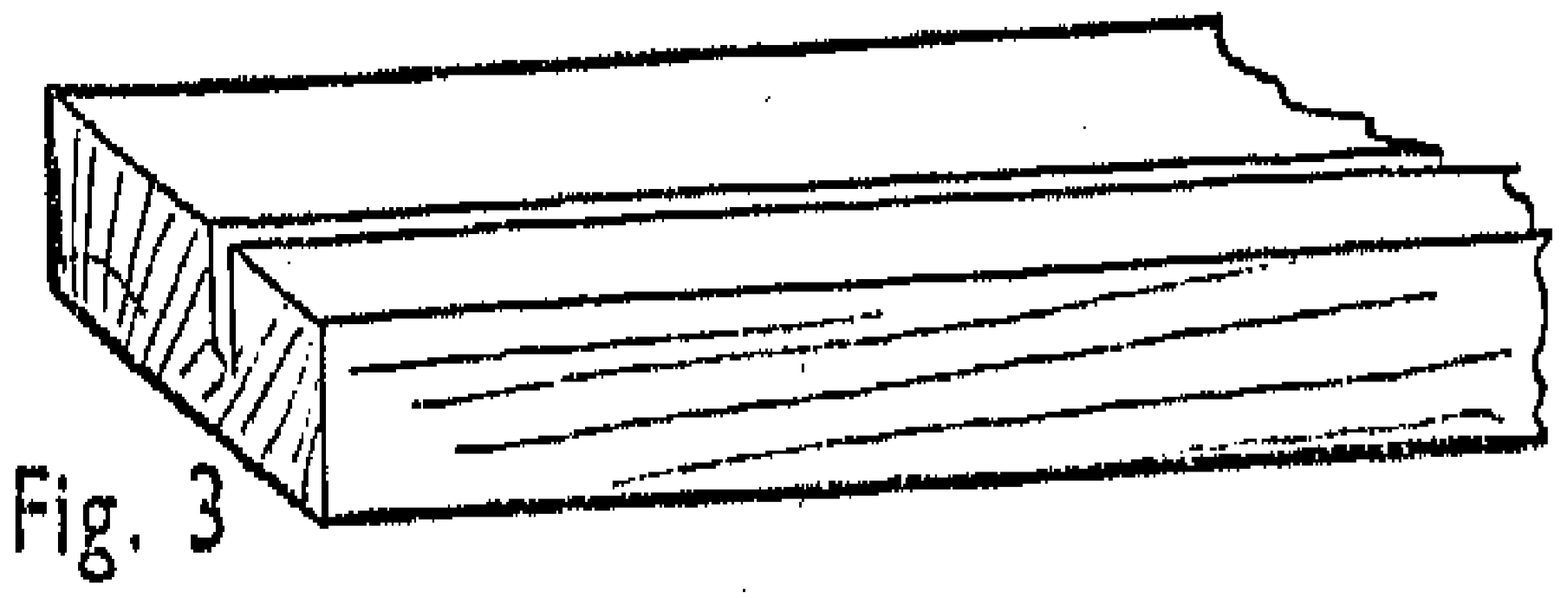


Fig. 3

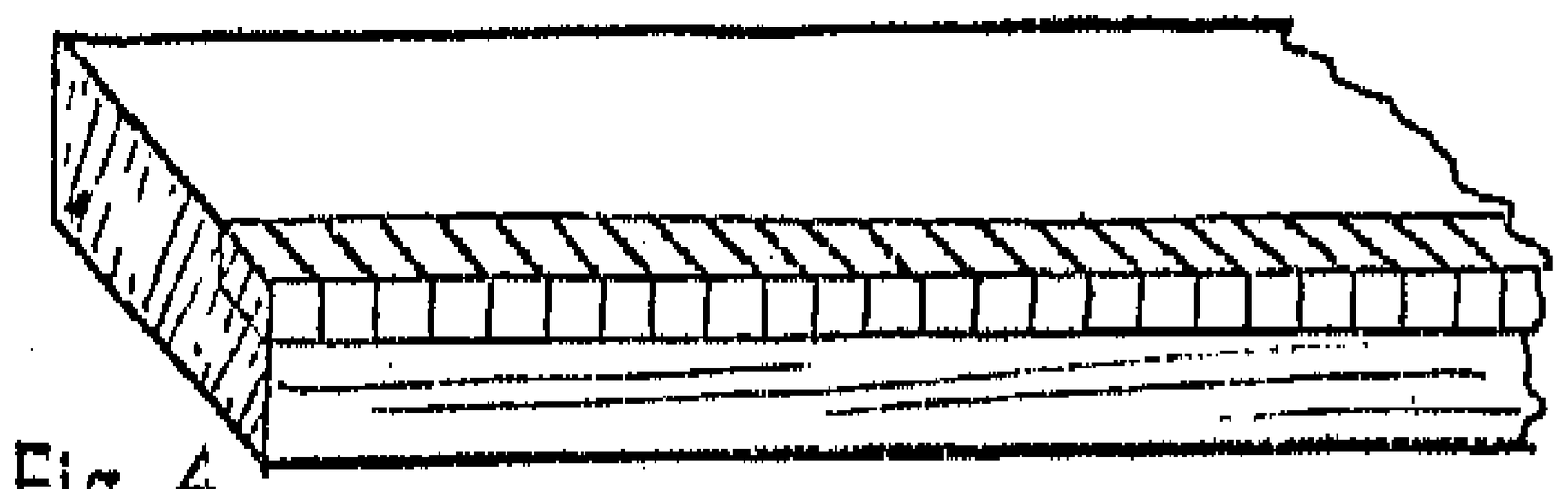


Fig. 4

Fig. 3 shows a groove after having been partly formed with a plough. The plough is first used to cut the groove to the correct depth and the remainder removed with a chisel. When using the plough, start at the front end and work gradually backwards until the full depth is obtained from end to end, and finish off by giving one or two strokes right along the work. Take great care to see that the guide is kept against the vertical face, otherwise the groove will be cut out of square.

As the average amateur does not usually possess either a rebate-plane or a plough, he must be content to remove the waste with a chisel.

Fig. 4 shows an easy way of doing this. Make a series of saw kerfs (cuts) across the front edge of the work, that is, from the depth line to the width line, by tilting the edge of the saw upwards, taking care not to cut past the marks. Now remove the waste with a chisel held obliquely so that the cutting-edge near the wall of the rebate is a little in advance of the other.

A Cutting-gauge having a very sharp cutter, as shown in Fig. 5, is a handy tool for cutting narrow, shallow rebates in good straight-grained timber. It should not be used, however, where the width and the depth exceed about ¼ in.

Fig. 6 shows a stopped rebate, so called because it stops instead of running the full length of the work. The recess is formed by first ploughing a groove and then chiselling out the waste.

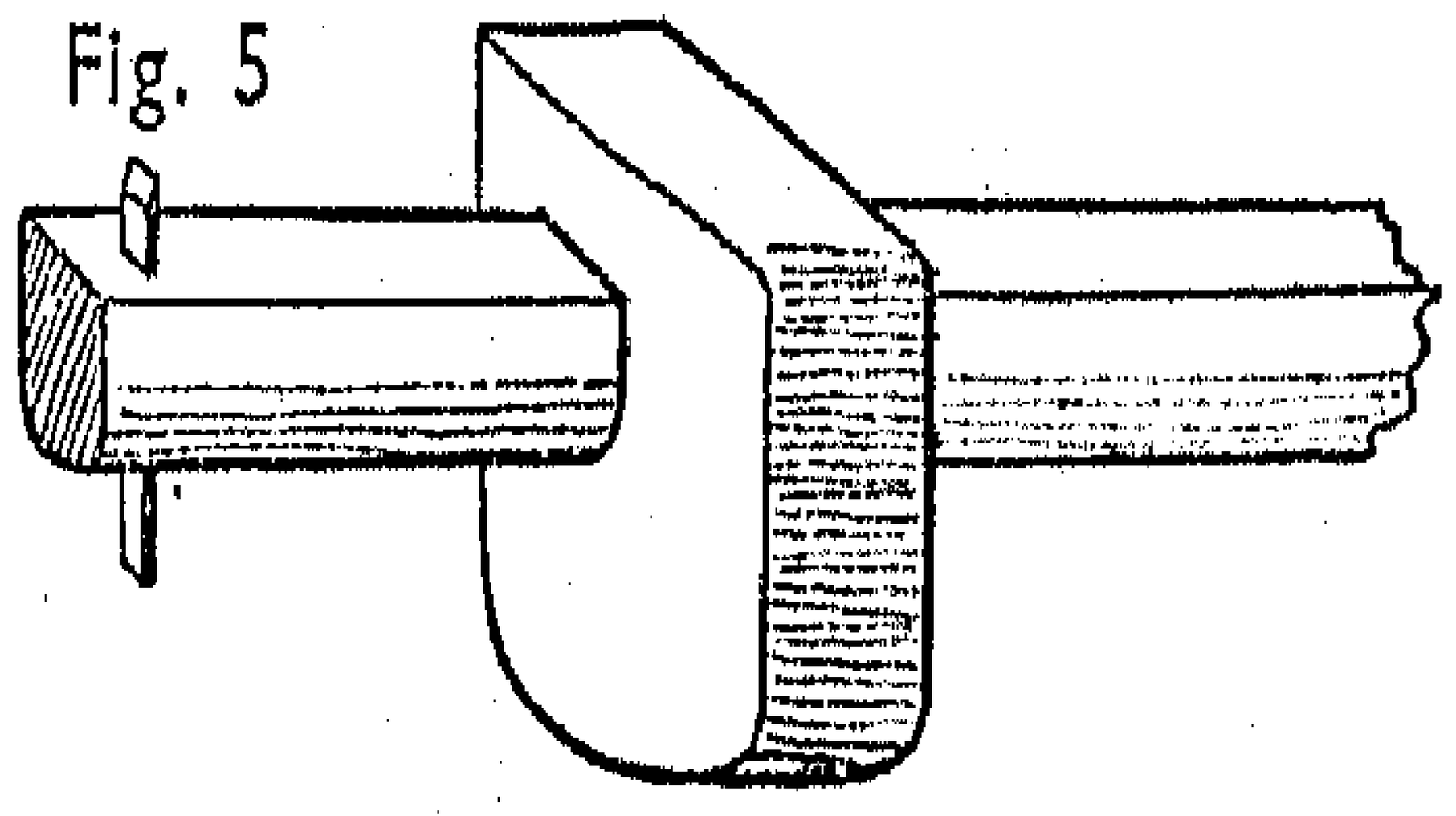
In cases where the rebate is made transversely to the grain, as indicated at B in Fig. 1, it is usual to have the material upon which the rebate is to be formed thicker than the piece to be joined. The depth of the recess is usually from one-half to one-third the thickness of the wood, and the width equal to the thickness of the piece to be joined.

After the gauge lines have been marked, the end is cut across to the correct depth with a tenon-saw, and the waste removed by one or other of the following methods.

For wide work the best way to remove the surplus, after cutting across the work at the gauge line, is to chisel it out (as shown at A in Fig. 7), and finish with a firmer- or, better still, a paring-chisel held horizontally as at B.

In cases where the wood is comparatively thick, first cut across it as previously mentioned and then place the work, narrow edge uppermost, on the bench and use the chisel vertically.

Fig. 5



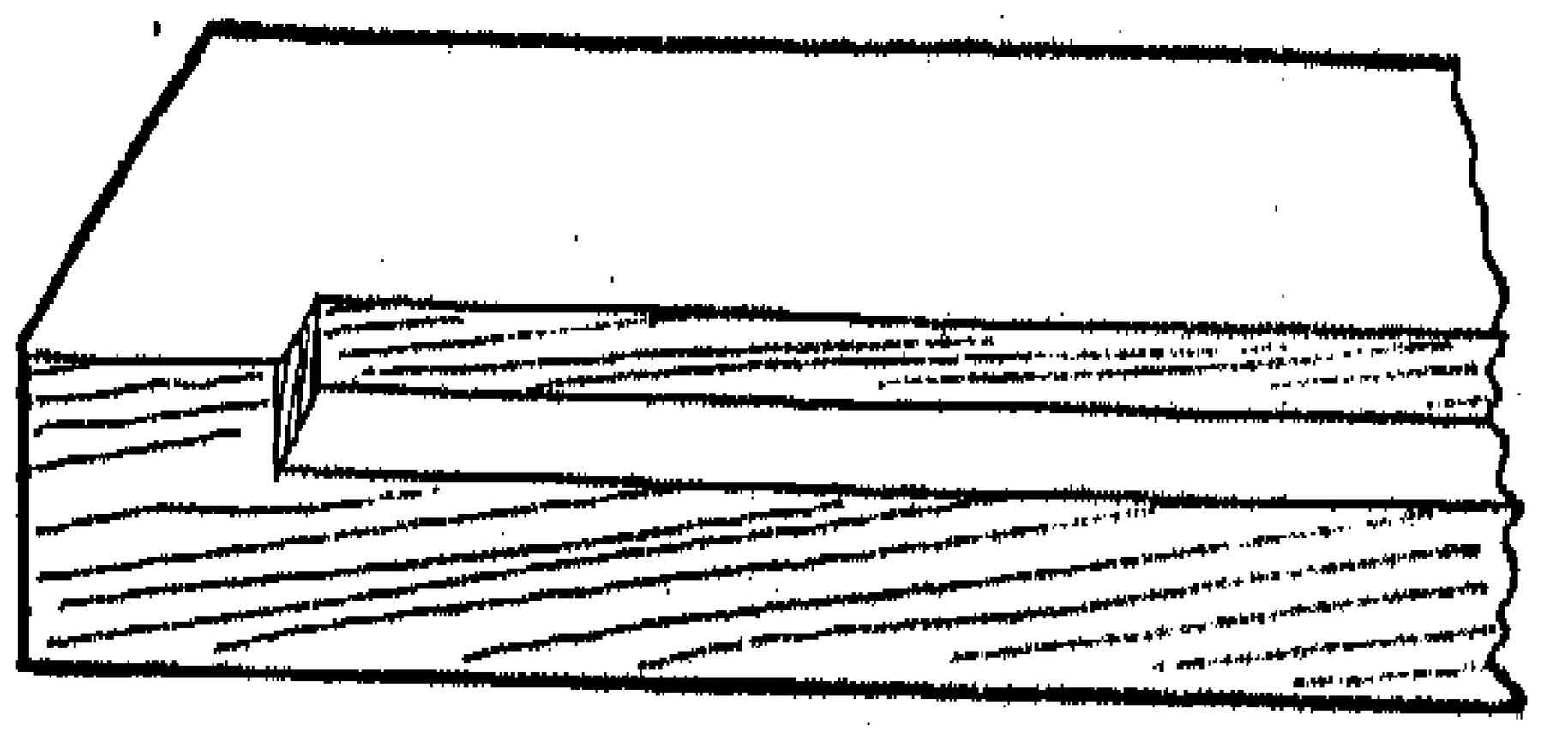


Fig. 6

Chamfering is a term used when removing a sharp edge to form a narrow, flat face, as that seen at A and B in Fig. 8. The edges of the wood are usually planed to an angle of 45°, the width depending upon the nature of the work. A chamfer forms a neat, narrow, flat surface which greatly enhances the appearance of a piece of work, as instanced in panelled framework, etc.

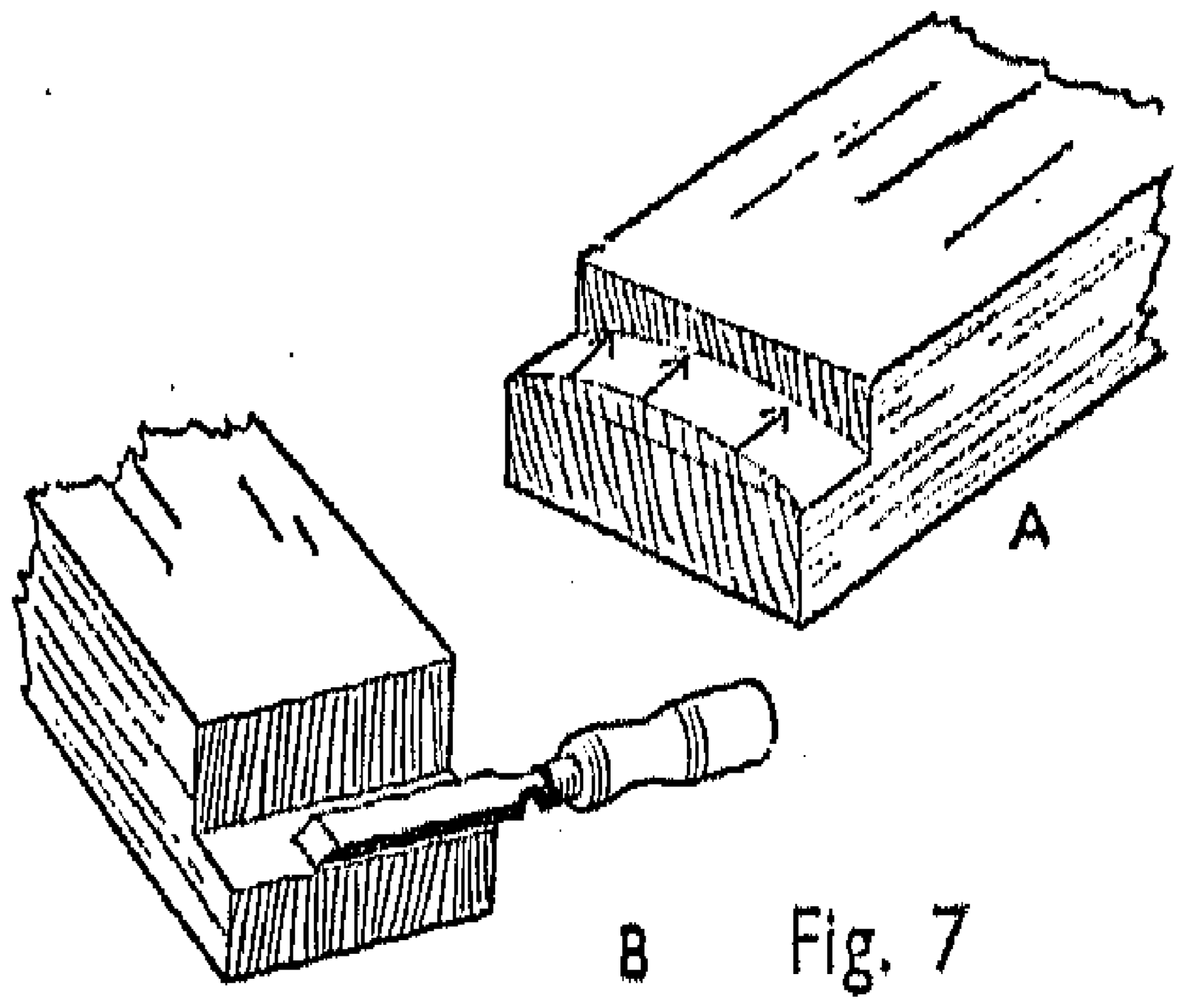


Fig. 7

The two chamfers in general use are known as the ordinary chamfer, where the bevel runs through the full length of the work, as indicated at A, and the stopped chamfer (B) which, as its name implies, stops before the ends are approached.

A Through Chamfer can be carried out with a jack or any other plane fitted with an iron whose cutting-edge runs straight across the sole, or with a proper chamfer plane. As the last-mentioned tool is seldom required by the amateur, there is no necessity to explain its function here.

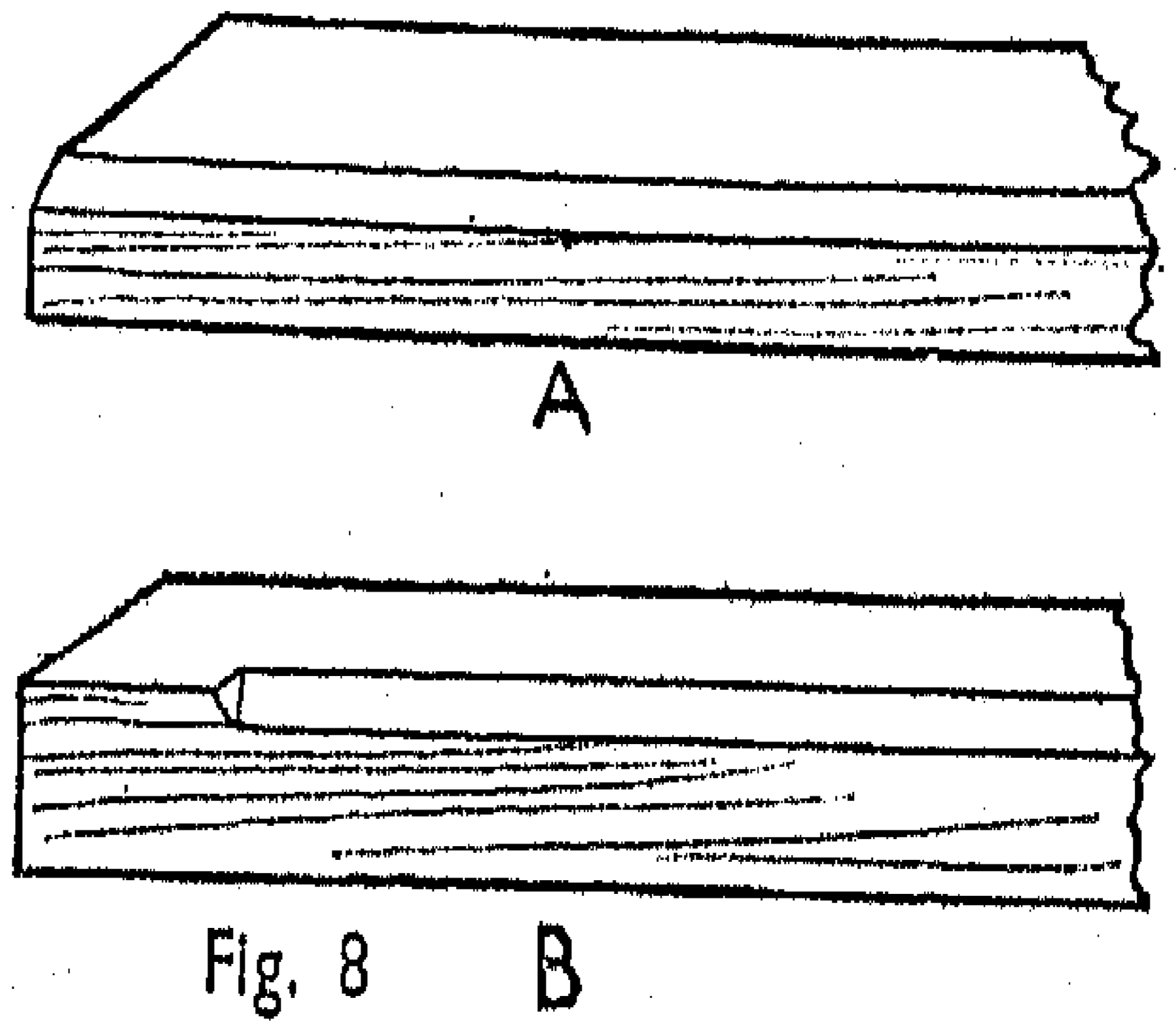


Fig. 8

To make a through chamfer, all that is necessary is first to mark a line parallel to the front edge on the face and side to be treated, and then plane down to the gauged lines.

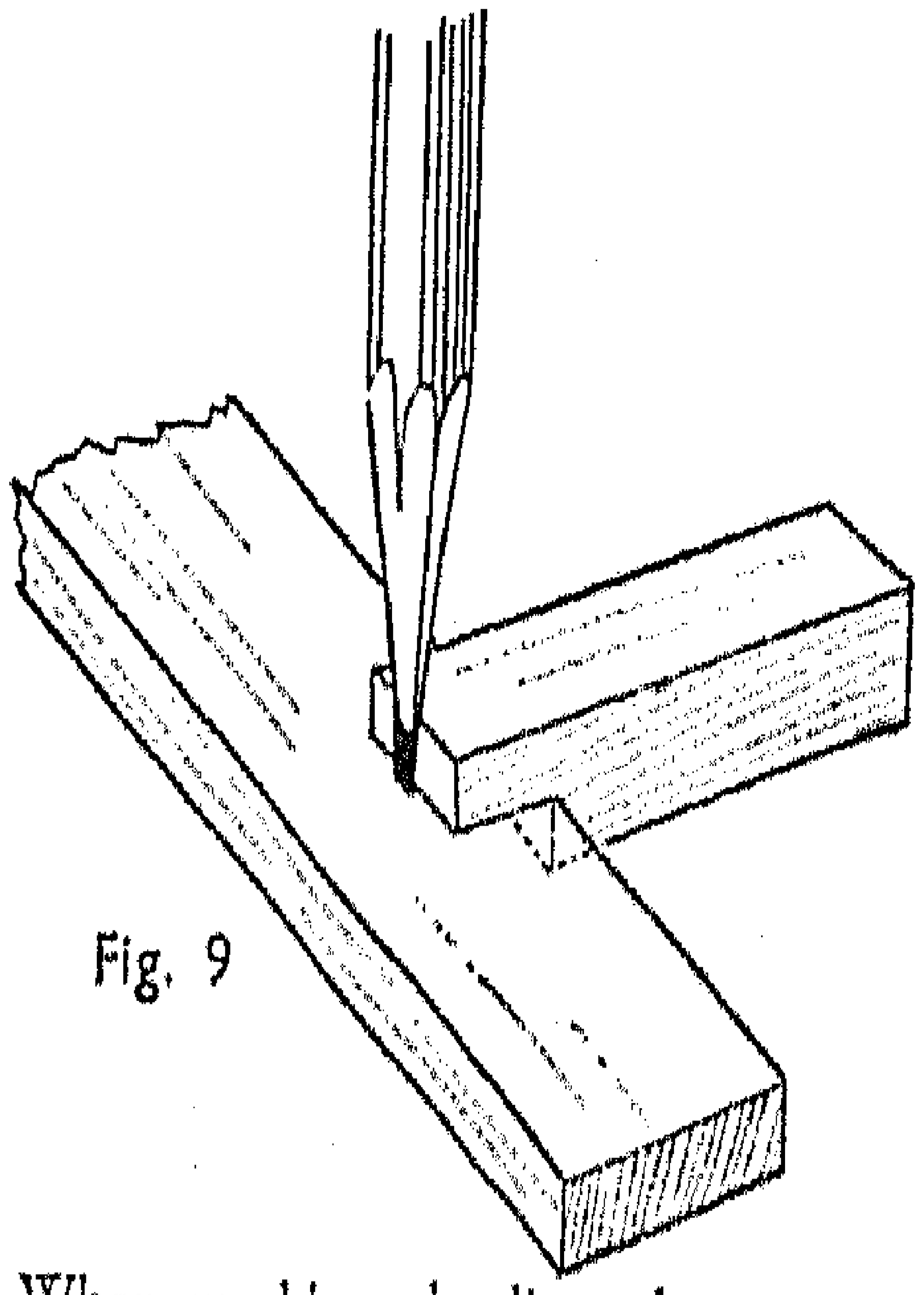
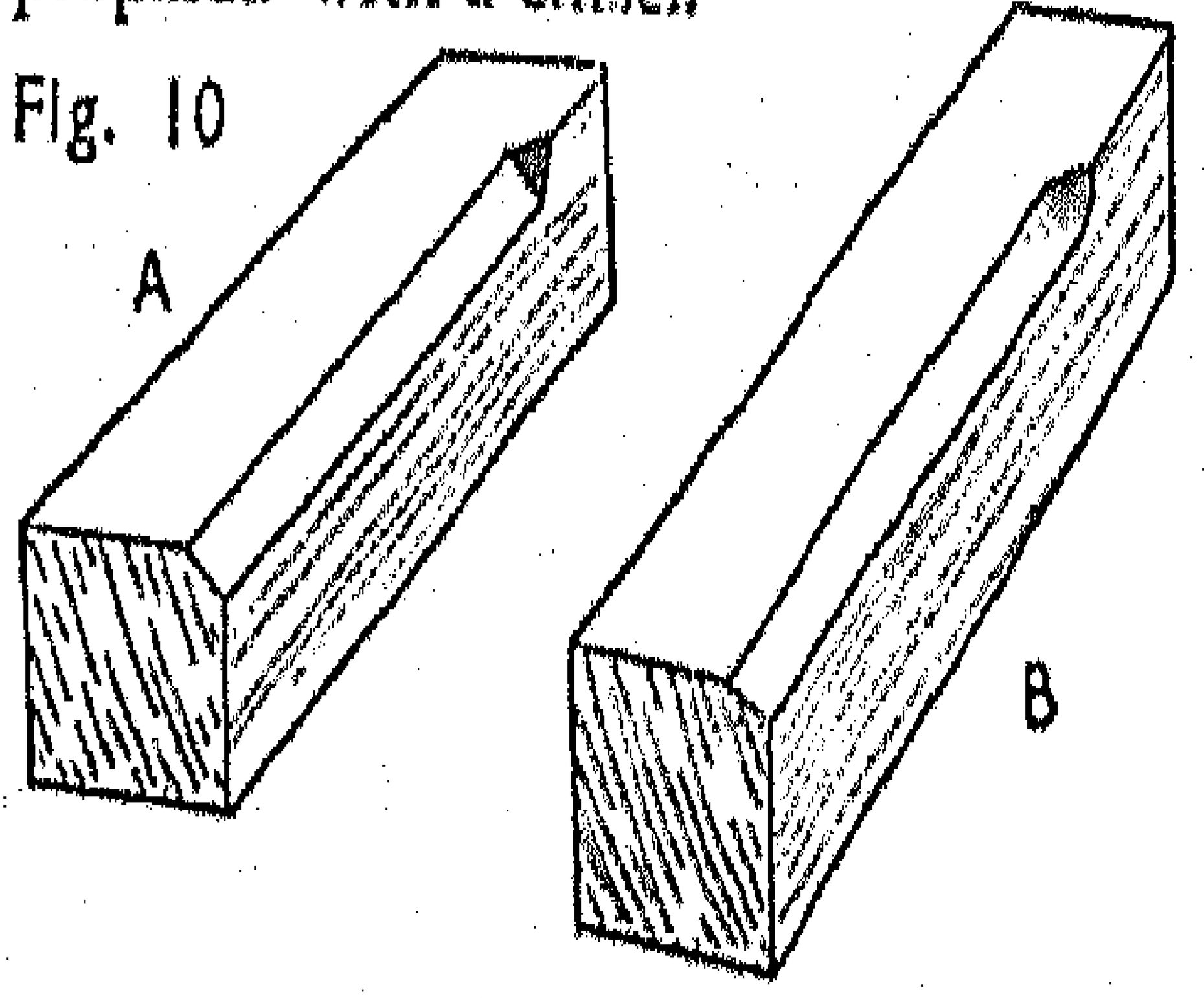


Fig. 9

When marking the lines do not use an ordinary marking-gauge as such, but remove the pin and substitute a short length of blacklead from a pencil. This will prevent damage to the edges of the work due to the sharp point of the pin. If this is not practicable, use a home-made gauge fashioned from a small piece of wood, as indicated in Fig. 9. A point to note when setting out the bevel is that the newly-formed face will be wider than the marked width at the edges.

In Forming a Stopped Chamfer, the stop is first sawn and chiselled out for a distance at least equal to the distance from the front of the plane to the cutting-edge of the iron, and then the intervening waste removed and finished with the plane. As it is unusual to stop the ends of the chamfers abruptly, one of the two common methods of finishing the stop, as shown in Fig. 10 at A and B, may be employed. They are, of course, prepared with a chisel.

Fig. 10



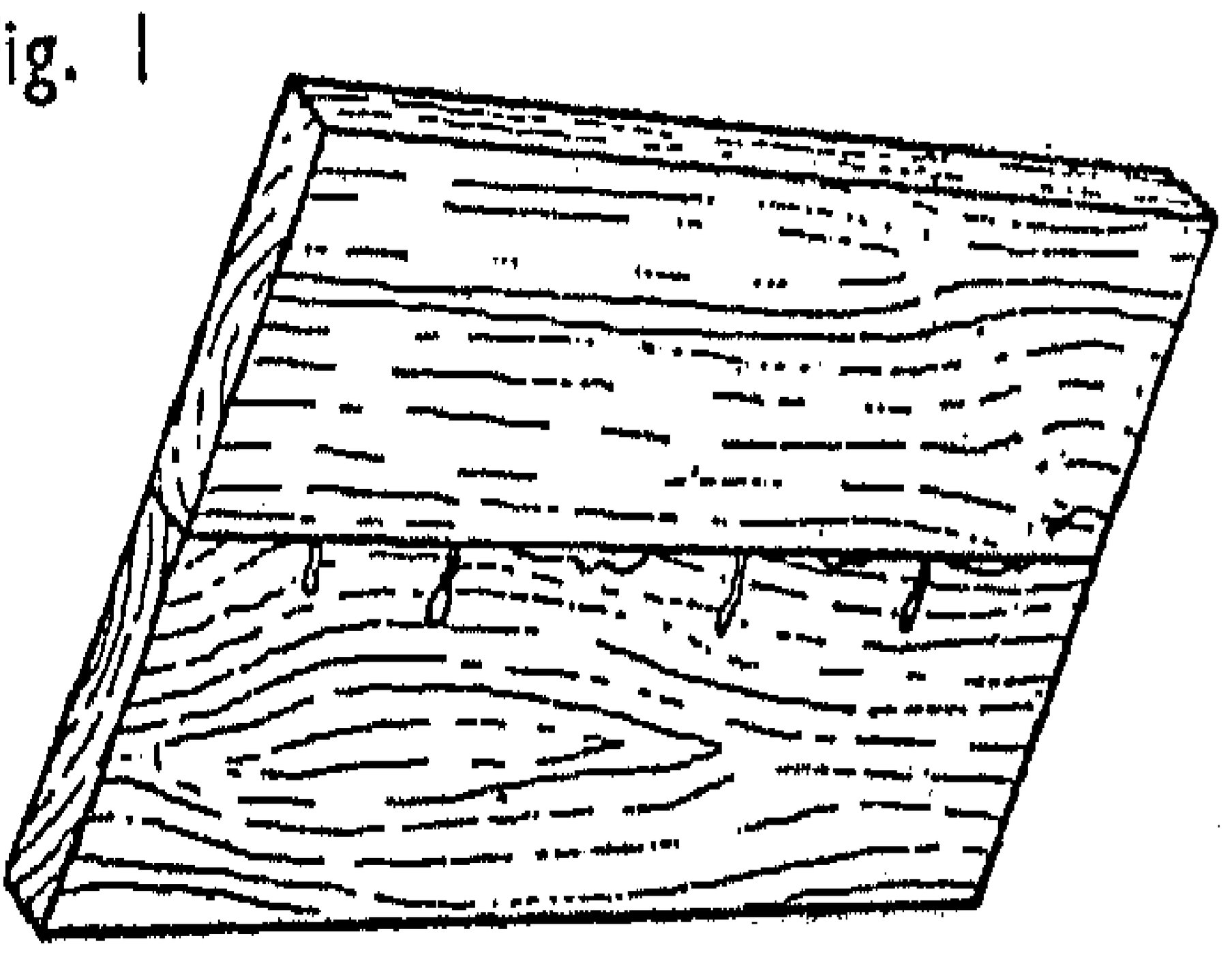
JOINTS AND JOINTING

WOODWORK joints may be classified under three headings, namely (*a*) angle joints, where the parts to be joined form an angle, as in the mortice and tenon joint; (*b*) those for increasing the width, as instanced in tongued and grooved boards; and (*c*) those employed for lengthening timber—usually confined to constructional work.

In describing the joints, mention will only be made of those likely to be of use and which can be easily made by the novice.

Glued Butt Joint.—The glued butt joint shown in Fig. 1 is a good test for careful planing. To make such a joint, true up the top and bottom faces of the pieces to be joined, and test for winding with the winding strips as explained in the section under PLANES AND PLANING. Next, true up one edge by planing the wood held either in a vice or on a shooting-board, and test for straightness by using a straight-edge. Make a pencil mark on this edge. True up the edge of the other board in a similar fashion and mark it as explained above. Now, whilst one board is in the vice—trued edge up—place the other board on it, that is, marked edge to marked edge, and test with the straight-edge in the manner shown in Fig. 2. If inaccurate, and reversing the board does not give a satisfactory result, the only alternative is to plane the edges again. If the joint is correct the boards may be glued together.

Fig. 1



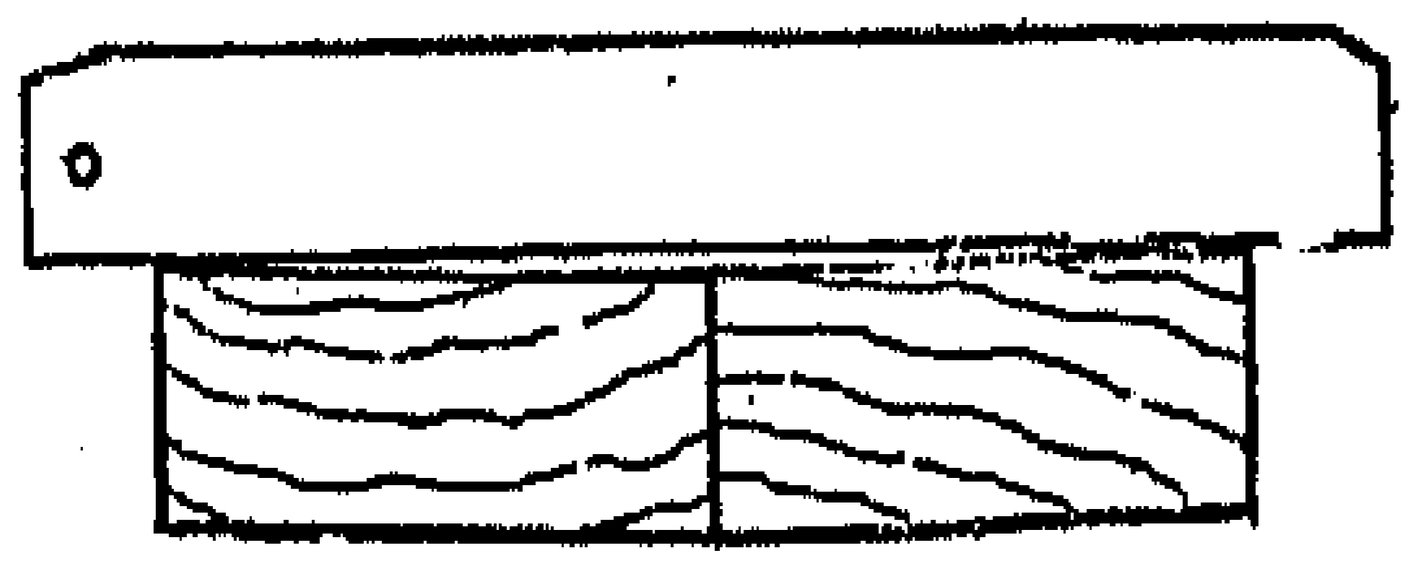


Fig. 2

Most softwoods take glue better than hardwoods, so when the latter are employed it is an advantage to draw the teeth of a tenon-saw down the face to be glued, to roughen it slightly.

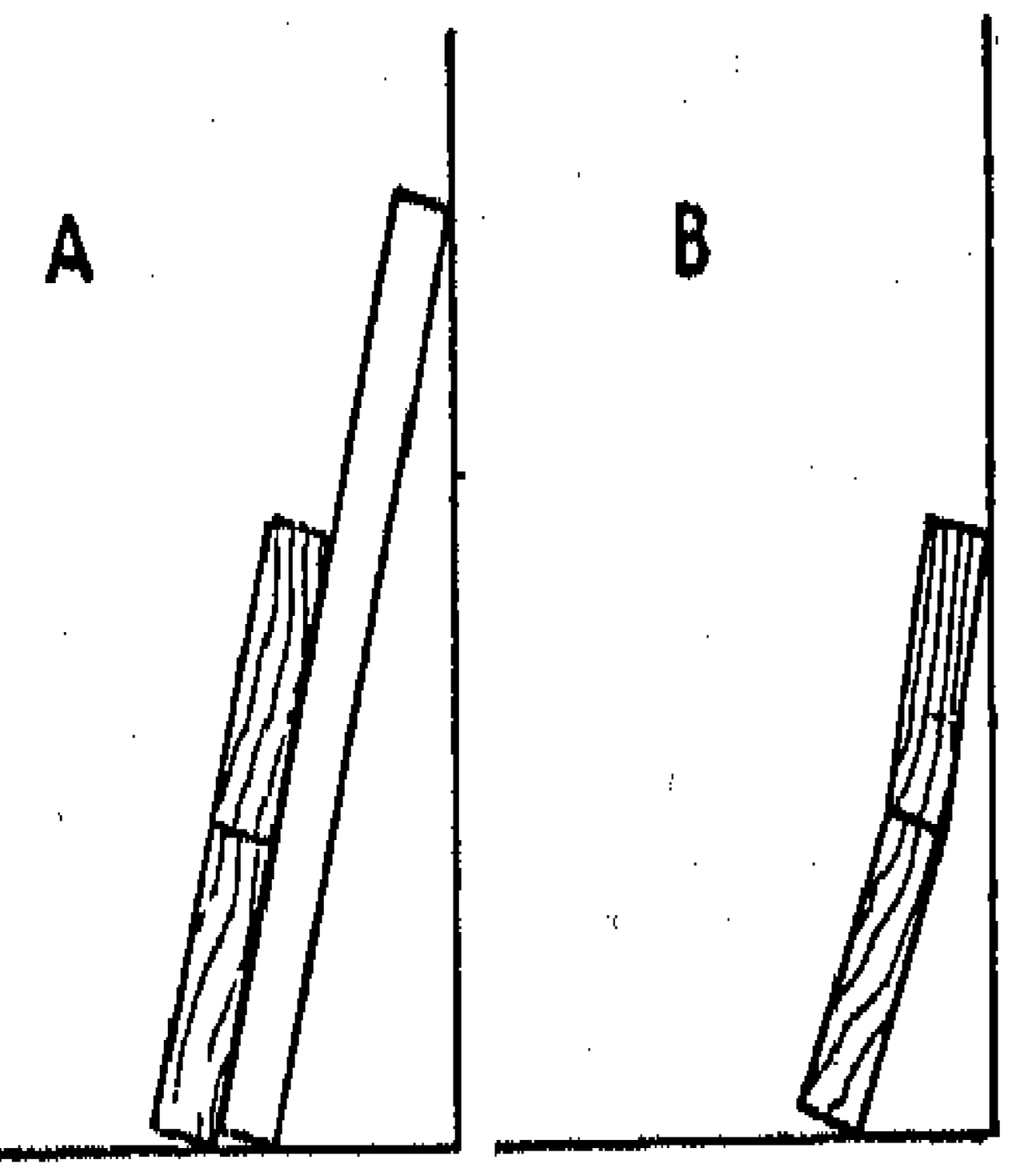
To make a successful glued joint, warm the pieces to be joined and apply a small quantity of glue to each edge, then rub the two pieces together in the direction of the joint to exclude the air. It may be pointed out that it is not the quantity of glue applied to the joint that counts, but the amount that can be squeezed out.

After the joints have been glued, the work should be set aside for about 24 hours to dry, taking care to lean the work against something flat, as shown at A in Fig. 3, otherwise the joint is likely to assume the shape illustrated at B.

Dowelled Butt Joint.—The ordinary glued butt joint may be greatly

strengthened by using dowel pins (as described in a later section and illustrated in Fig. 4). When dowels are used the rubbing process for excluding the air after gluing obviously cannot be accomplished.

Fig. 3



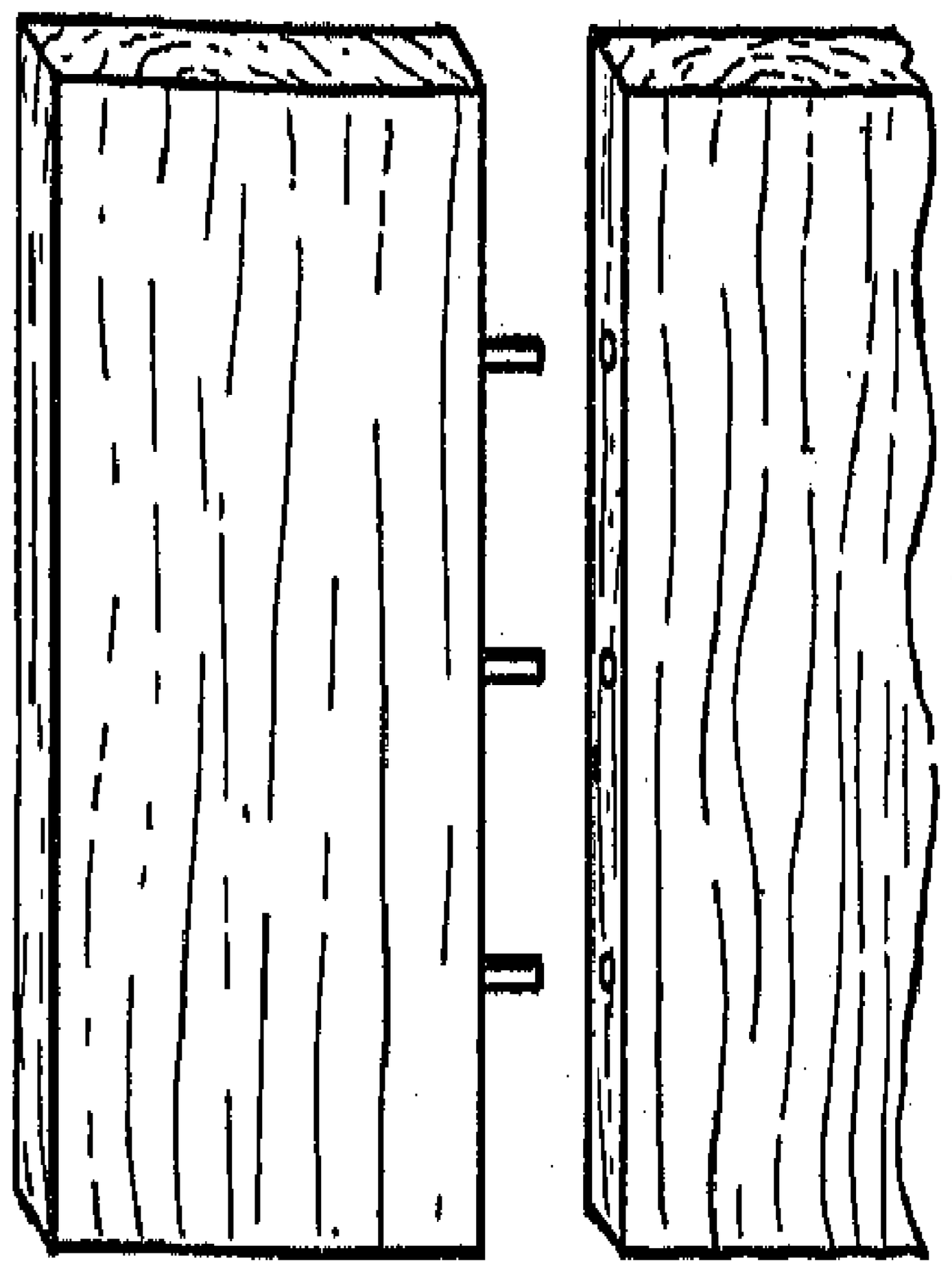


Fig. 4

Tongued and Grooved Joint.—Another method of joining the long edges of boards is by means of tongues and grooves as instanced in the tongued and grooved matchboards and floor-boards, as shown at A, B and C, Fig. 5, which can be purchased ready for use.

When dealing with plain-edged boards, the tongue and groove may be formed with planes sold in pairs to match, or by using a single grooving-plane. In the latter case, the edges of the boards to be joined are first grooved and then a separate tongue is inserted in the grooves. When a separate tongue is used it is advisable to make the tongue from a piece of wood cut across the grain, as this method is very much stronger than using a piece cut with the grain. This can be readily proved by trying to break the two tongues. The tongue should be of sufficient thickness to fit snugly in the grooves yet leaving enough clearance for the surplus glue when gluing up.

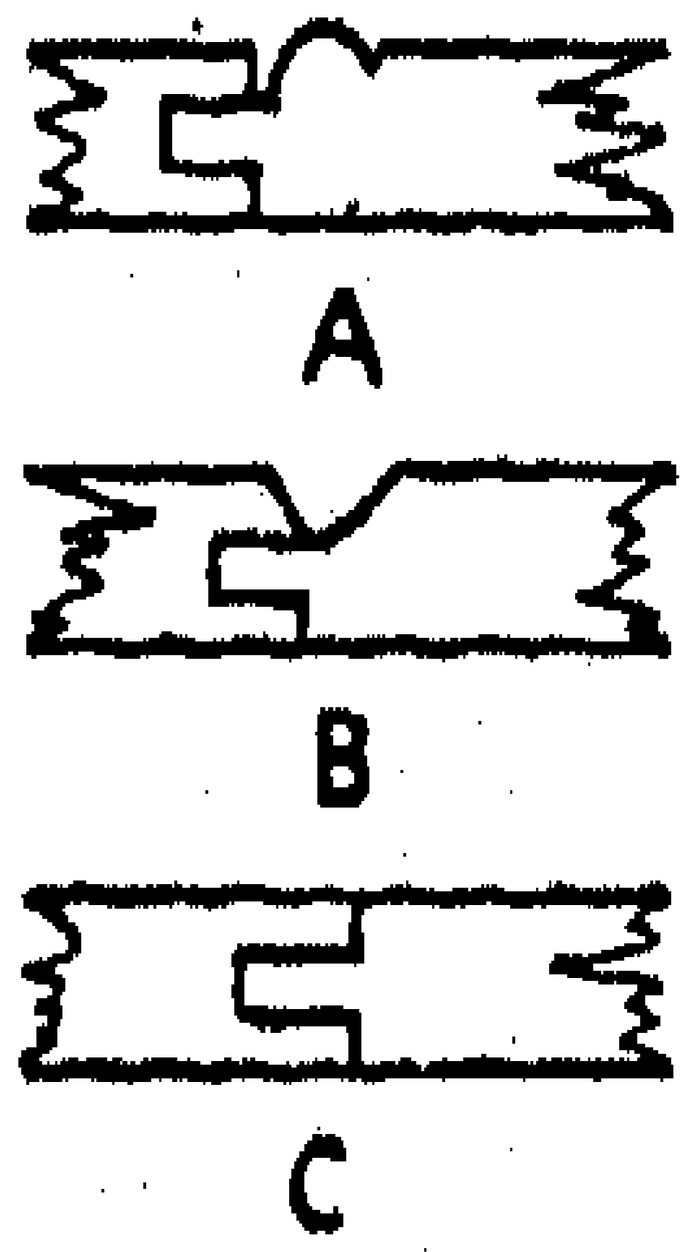
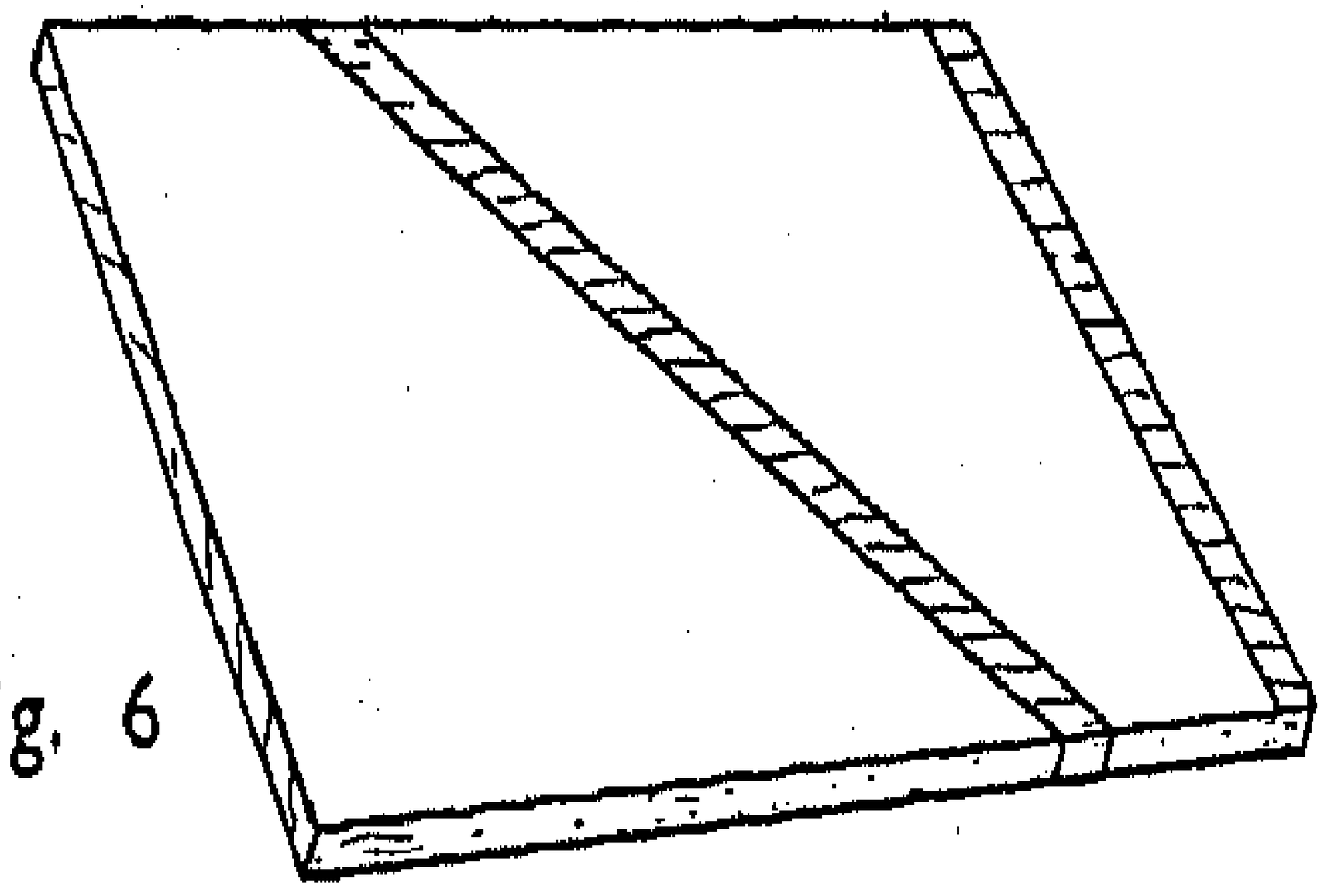


Fig. 5

The board from which the tongues are prepared should be planed to the required thickness before cutting to length, as difficulty will be experienced in planing across the grain if cut first and then sawn into strips. Fig. 6 shows the most economical way of cutting the tongues.

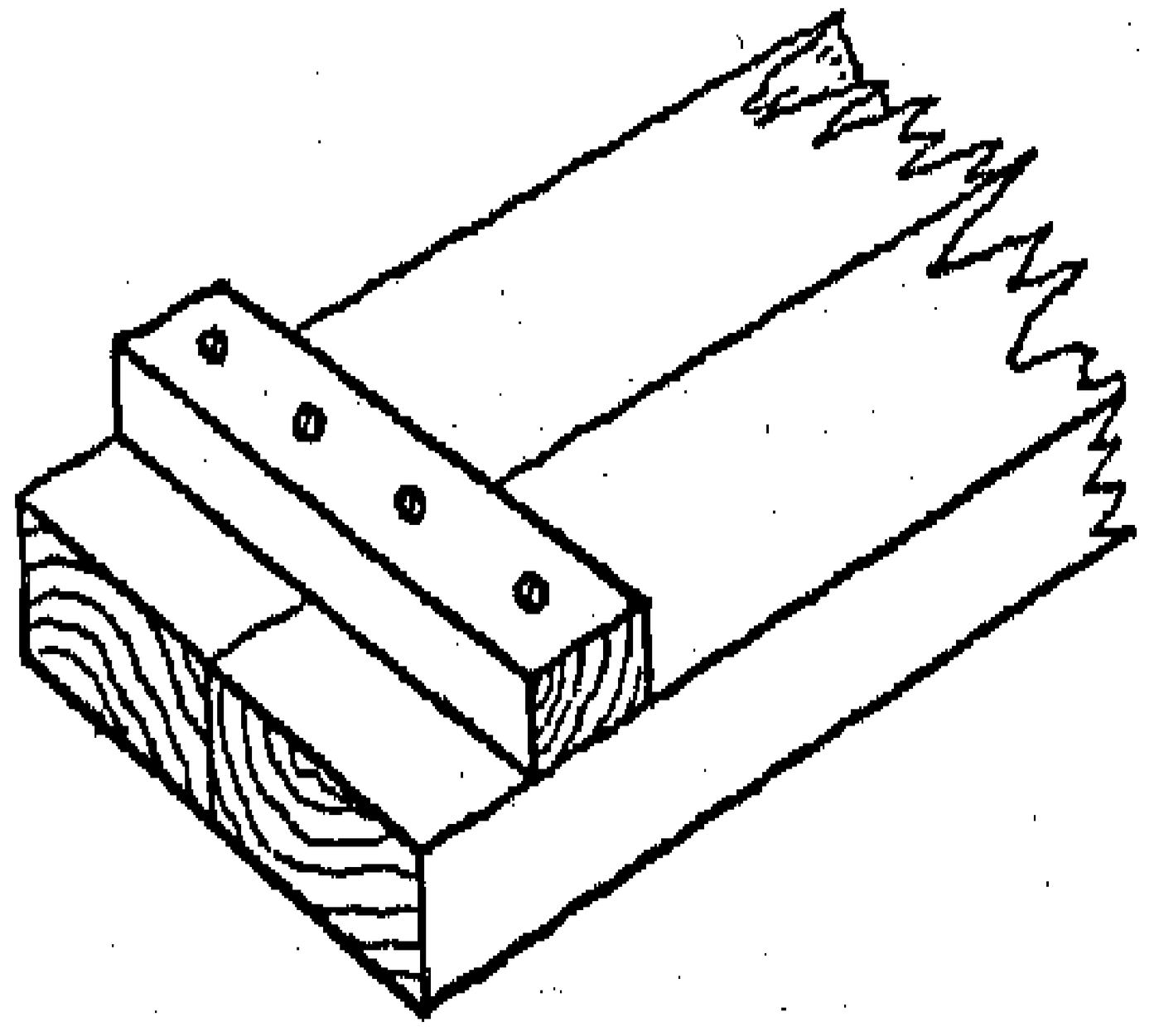
In some cases where the quality of the finish is immaterial, cross-pieces may be either screwed or nailed to the boards, not only to strengthen the joint but as an aid against twisting. This is shown clearly in Fig. 7.

Fig. 6



Screwed Butt Joint.—Fig. 8 shows another method of joining the long edges of boards. In the example a depression is gouged out near the edge of one piece, deep enough to take the head of a screw. A hole is then bored to take the screw,

Fig. 7



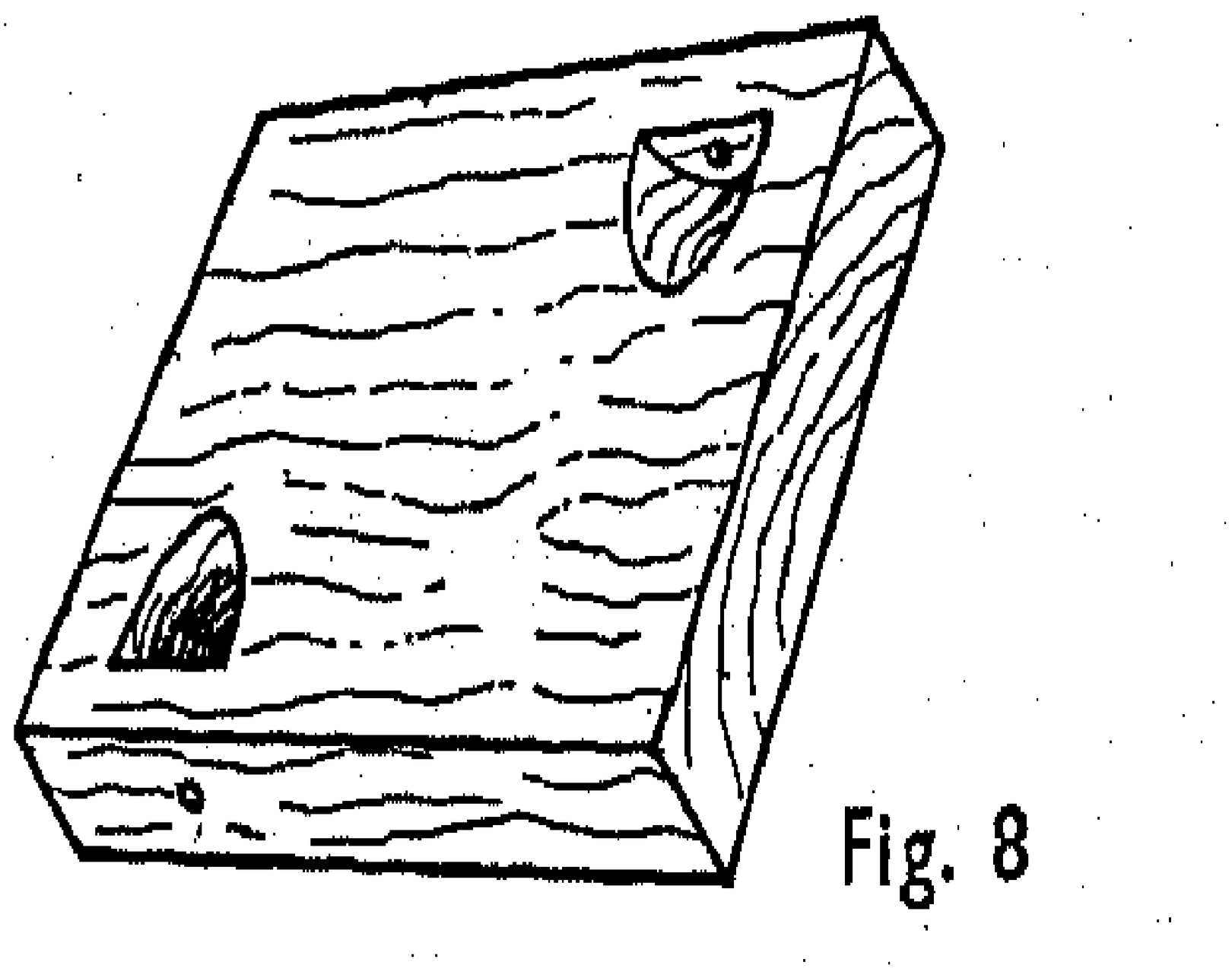


Fig. 8

which is inserted and screwed tightly into place after the boards are glued together.

Joint made with Corrugated Fastener.—The handy little device illustrated in Fig. 9 is useful for making a butt joint. It is composed of a thin piece of corrugated steel having sharp edges. It is simply driven into the ends of the wood, the corrugations preventing the members from being pulled apart. Corrugated fasteners are used extensively for 'making packing-cases and articles of a similar nature where a good close joint is required but where there is no necessity to go to the trouble and expense of making, for instance, a glued butt joint.

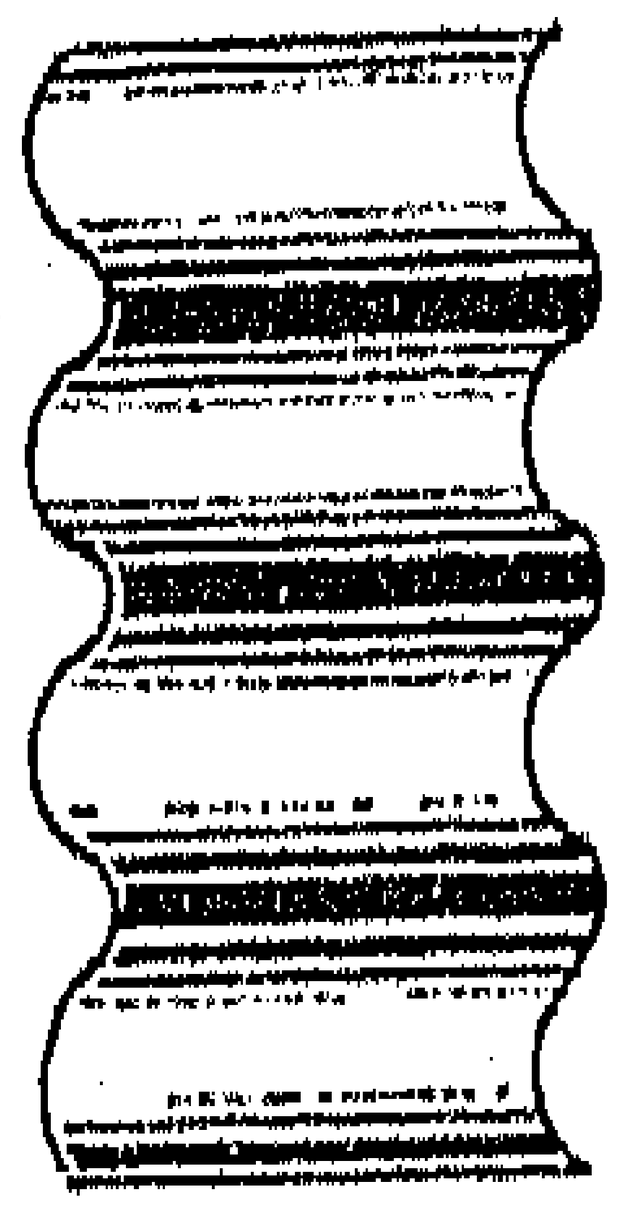


Fig. 9

Battened Butt Joint.—When making a drawing-board or an object of a similar character such as a dresser or a table-top, where great care is needed to avoid possible shrinkage and twisting, the joint illustrated in Fig. 10 may be used with advantage. In the case of a drawing-board, the separate pieces to be joined (A and B) may be either butt-jointed or tongued and grooved, and further strengthened by carefully trued-up battens fixed on the underside by round-headed screws. The cross-pieces have a number of slots cut in them depending upon the width of the board, the slots being just wide enough to take the unthreaded part of the screw. Brass sockets, obtainable for the purpose, cover the slots and offer less friction to the screw when the board either shrinks or expands. In this way the battens are enabled to do their work as if they were screwed direct on to the boards they are intended to keep from twisting.

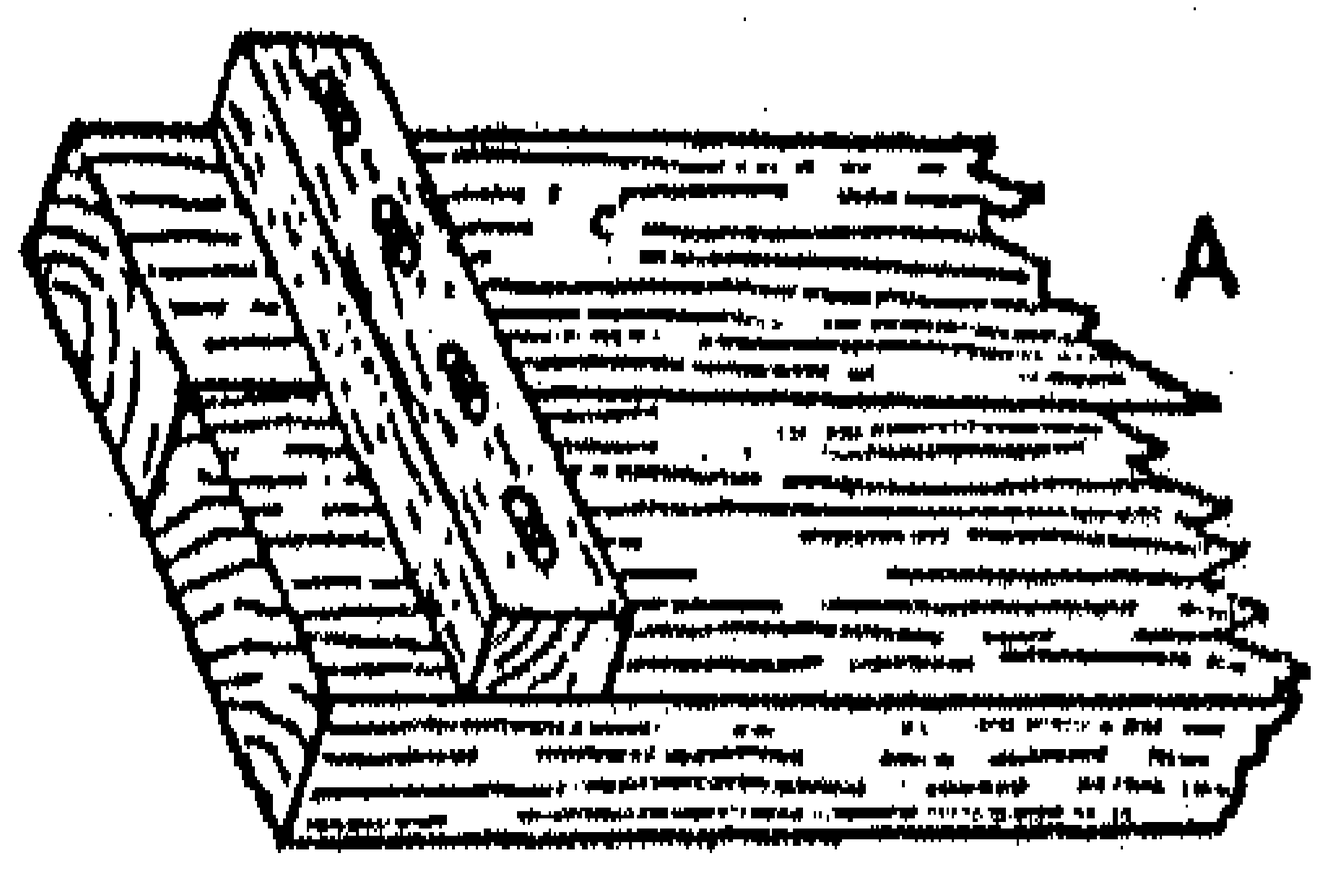


Fig. 10

Simple Ledged Joint.—Fig. 11 shows a simple yet effective joint commonly used at the ends of boards to prevent twisting. The joint is used extensively in the making of cheap drawing-boards, pastry-boards, etc. The ends of the boards are tongued and fit into grooved battens which are fixed by either nails or glue, or both.

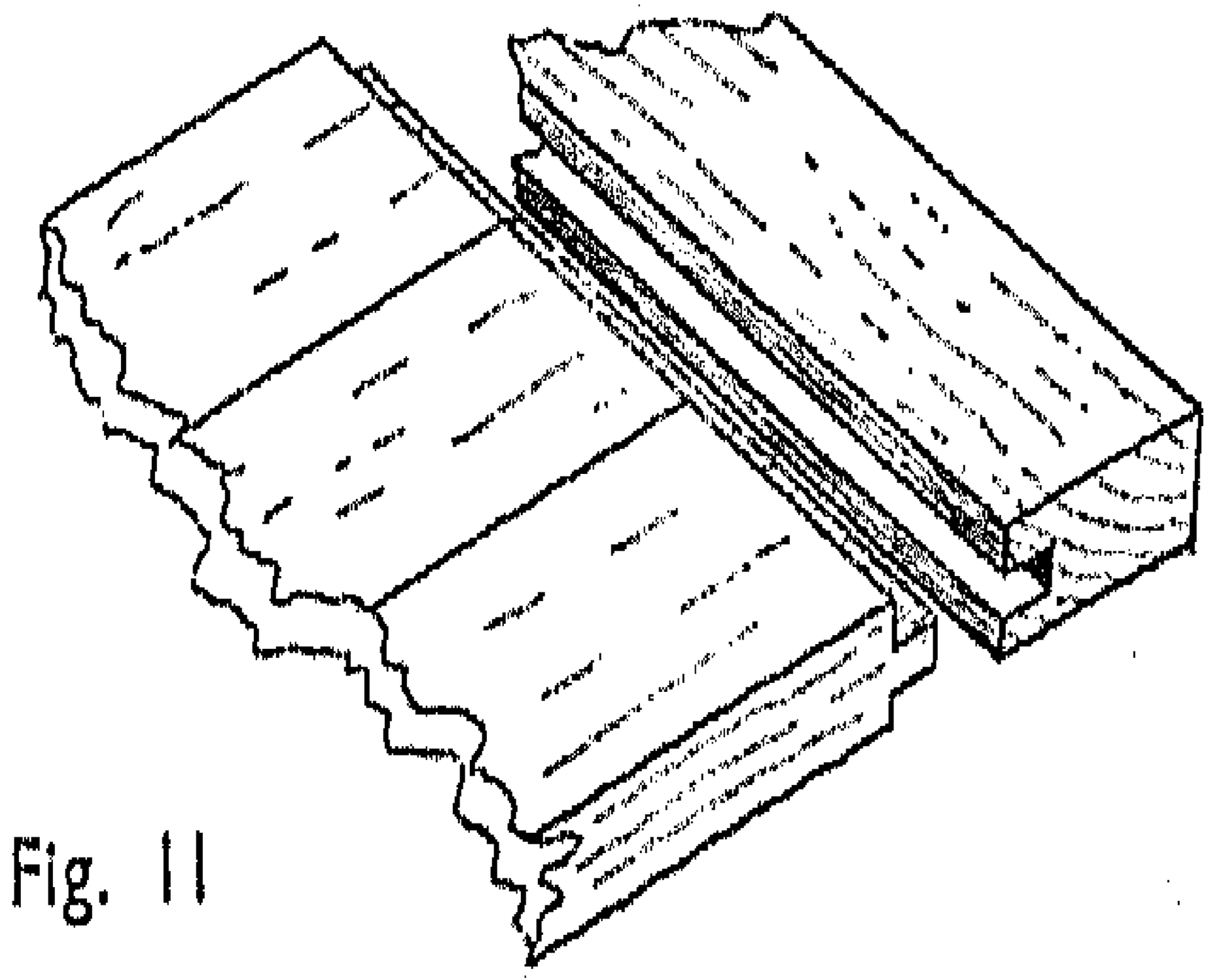


Fig. 11

Another type of ledged joint is represented in Fig. 12. It is useful when a large surface, such as a table-top, is to be fixed to a framework, as it prevents twisting and shrinkage. The table-top is fastened to the framework in the usual way by gouging a recess—similar to that shown in Fig. 7—in the sides of the framing and driving screws through it into the top. A groove is also provided near the top edge of the framing and small blocks of wood screwed to the underside of the table-top. The blocks can be made of any kind of hardwood such as mahogany, oak, etc., and should be shaped as indicated in the drawing.

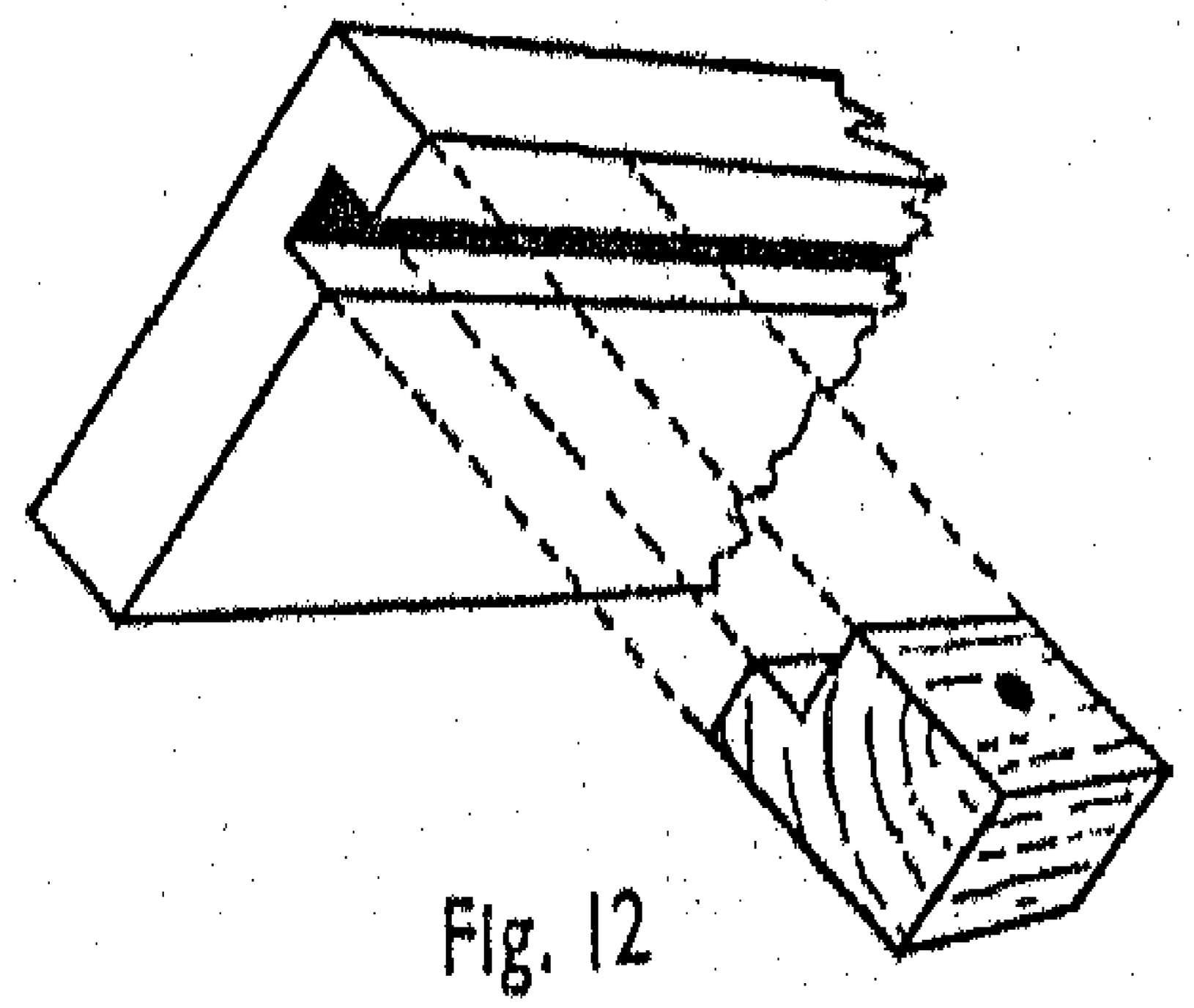


Fig. 12

The types of angle joints used by the woodworker are legion, but the most important from the amateur's point of view are perhaps halving, housing, mortice and tenon, and dovetailing, although the latter joint is seldom required.

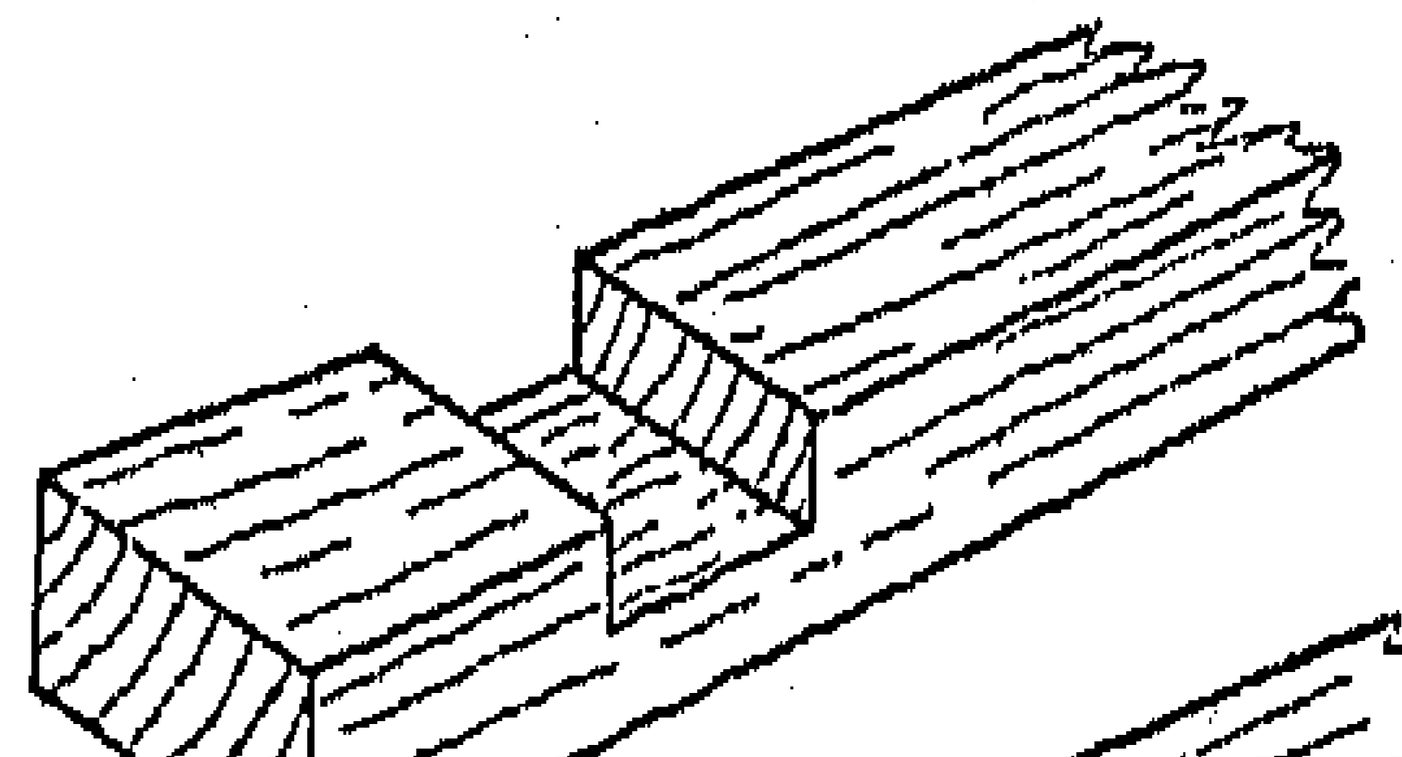


Fig. 13

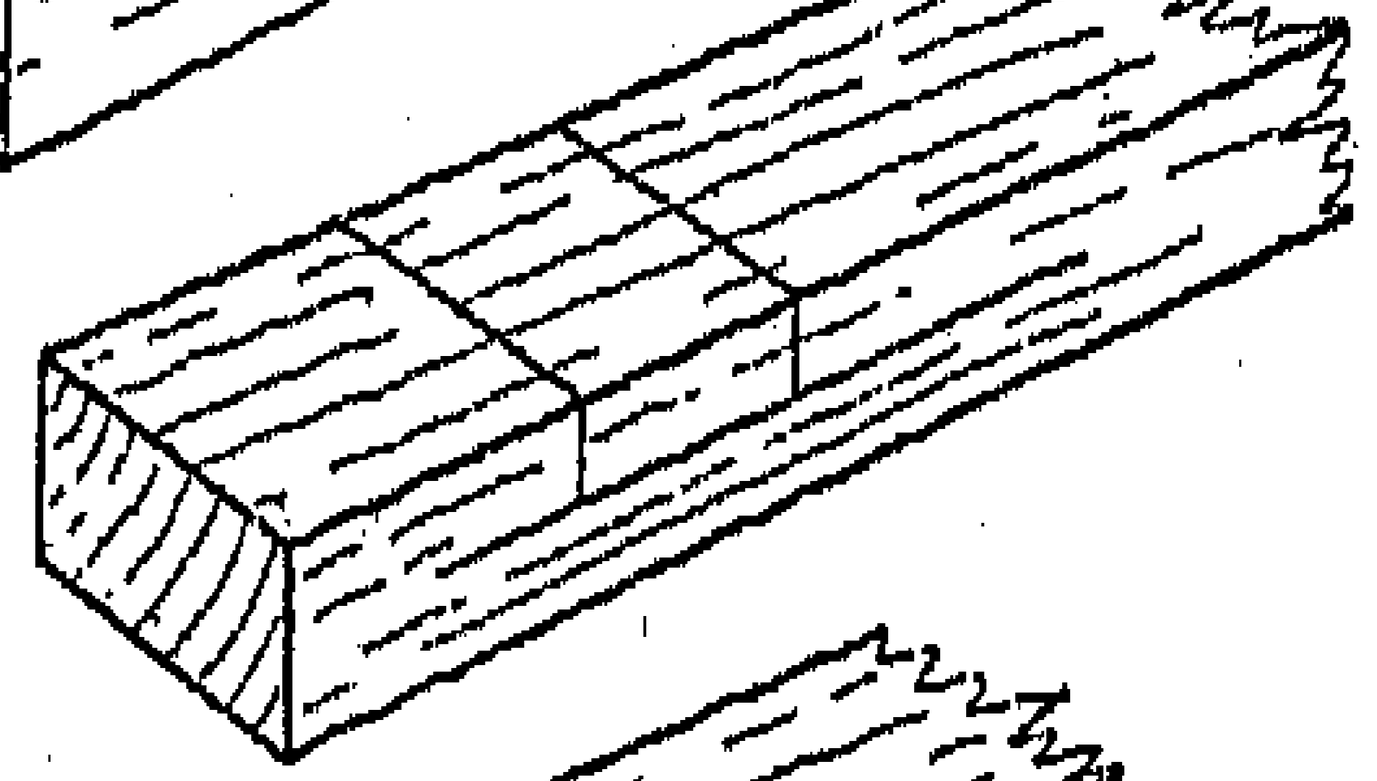


Fig. 14

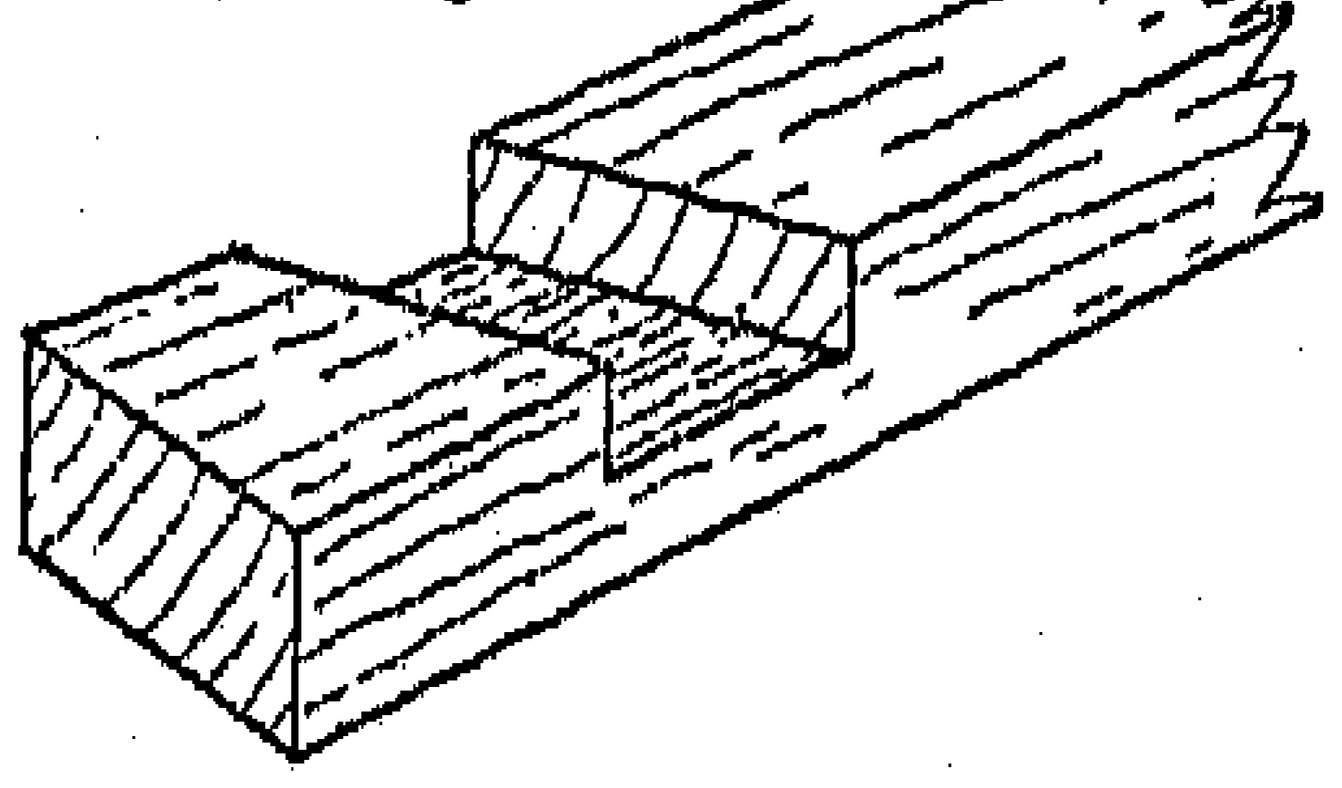


Fig. 15

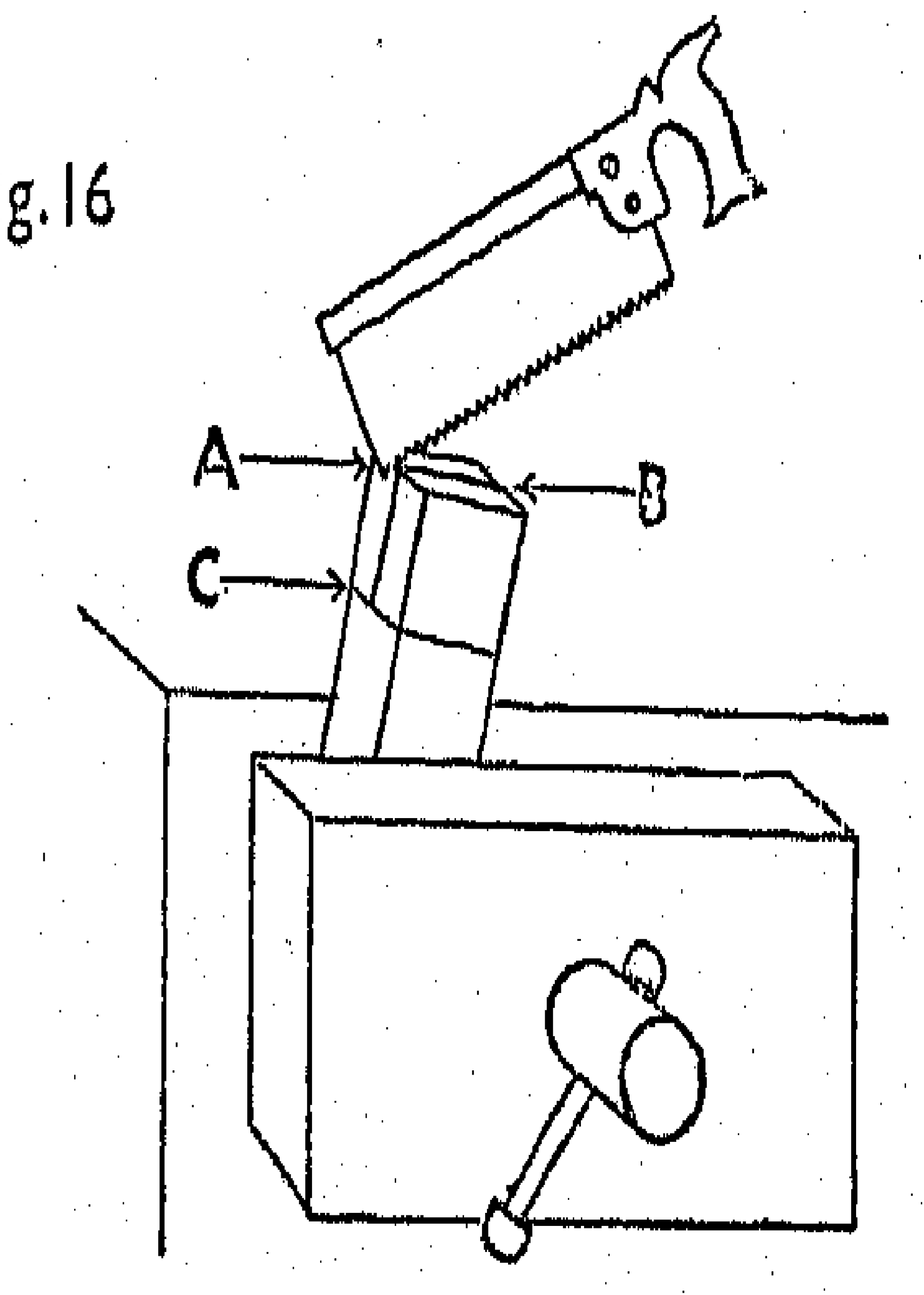
Halved Joint.—The halved joint is used for many purposes and takes many forms. As its name implies, the material of each piece to be joined is half cut away. In the cross halved joint illustrated in Fig. 13, one piece is cut away as shown. This piece is laid across the second piece, which is then marked and cut out in a similar way. The depth of the cut is marked with a marking-gauge, and the position of the cross-cuts squared across and marked with a scribing-knife. Care should always be taken to saw in the waste side of the mark, that is, the part of the wood to be cut away. The cross-cutting is sawn, of course, with a tenon-saw, and the waste removed with a firmer-chisel.

A good-fitting joint should be hand tight, that is, one piece will just hold the other by friction and yet can be easily separated by means of the hands.

To make the Joint, first plane up the timber truly square as tested by a straight-edge and square. Do not trust to timber purchased ready planed, as it may not be perfectly square. Measure up exactly where the joint has to be by laying one piece across the other, and scribe a line on each side with a scribing-knife or a penknife. Test these lines with a square. Now square down the edges of the wood. Take the marking-gauge and set it to half the thickness of the piece of wood. To prove accuracy of setting, make a gauge-prick on another part of the wood, first from one side and then the other. If the two indentations correspond you know you have the exact half. Gauge-mark both sides of the wood from one face. Fig. 14 shows the joint marked out.

Place the timber in the vice or on the sawing-stool and saw down to the proper depth, taking care not to cut below the depth-marks, otherwise the joint will be considerably weakened. The waste material may now be chiselled away by using a firmer- or a paring-chisel. Do not chisel right through to the farther side as you are likely to break the farther edge, but work towards the middle from each edge.

To test for accuracy of the chiselled surface, lay the long edge of the chisel across the bottom of the cut. If the chisel rocks easily it indicates that the base is high somewhere about the centre. This fault must be rectified, but in doing so be careful not to make it hollow.

Fig. 16


This finished piece may now be laid across the other and tested for squareness with a try-square. The other piece of wood is treated in exactly the same manner.

Angled Halved Joint.—Fig. 15 shows a halved joint set at an angle. It is made in exactly the same way as the right-angled joint mentioned above, except, of course, that the faces are marked out and sawn to the required angle.

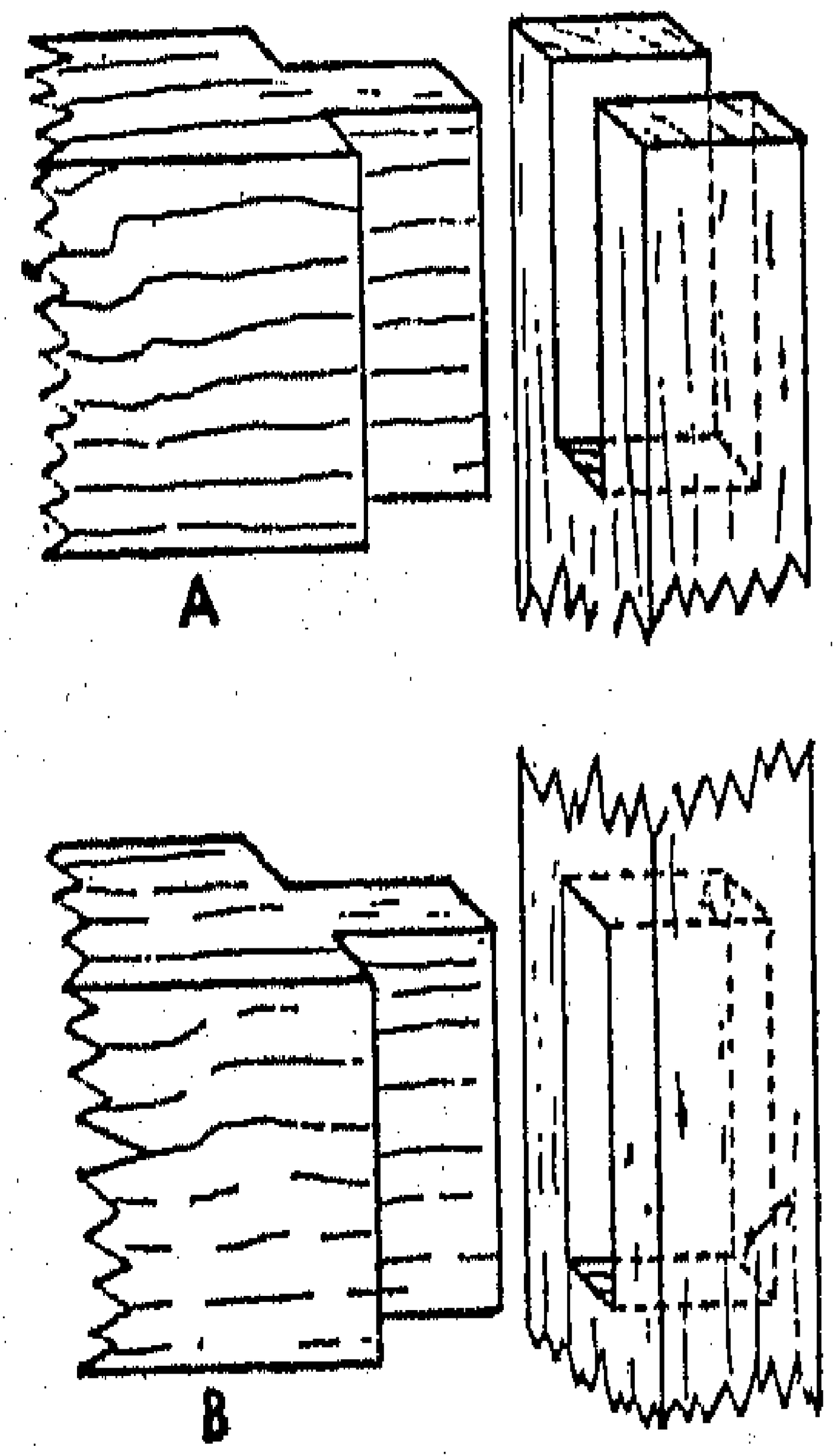


Fig. 17

T Halved Joint.—In making a T-joint, where the end of one member is cut away to fit the piece forming the top of the T, it is a good plan to fix the tail-piece in the vice and saw out the waste in the manner indicated in Fig. 16. Gauge the piece as previously explained, and run the marking-gauge round the two sides and the end. Place the wood in the vice, with the top slightly sloping towards you. Start the cut at the top edge as indicated at A in the illustration, and saw along the end until the edge B is reached. Push the wood over, keeping the saw in the saw cut and saw down to the gauge mark at C. Now turn the work round and saw down the other side in the same fashion. The cut can then be made level and the waste piece cut off.

This finished piece can now be placed on the second piece for marking purposes, and when this is completed, the recess can be formed with the aid of the saw and chisel.

The same routine is carried out in making similar T-halved joints where an angle other than a right-angle is desired.

Mortice and Tenon Joint.—The mortice and tenon joint is one of the most important joints in woodwork where strength and rigidity are required. There are numerous forms of this useful joint, a good many of which are not likely to be used by the amateur woodworker. The mortice and tenon joint is a much stronger and more satisfactory joint than the halved joint, and is formed by cutting a rectangular tongue on one member to fit a corresponding cavity in the other.

An ordinary simple slot or open mortice and tenon joint ready for fixing is shown at A in Fig. 17, and that at B represents a through T-joint.

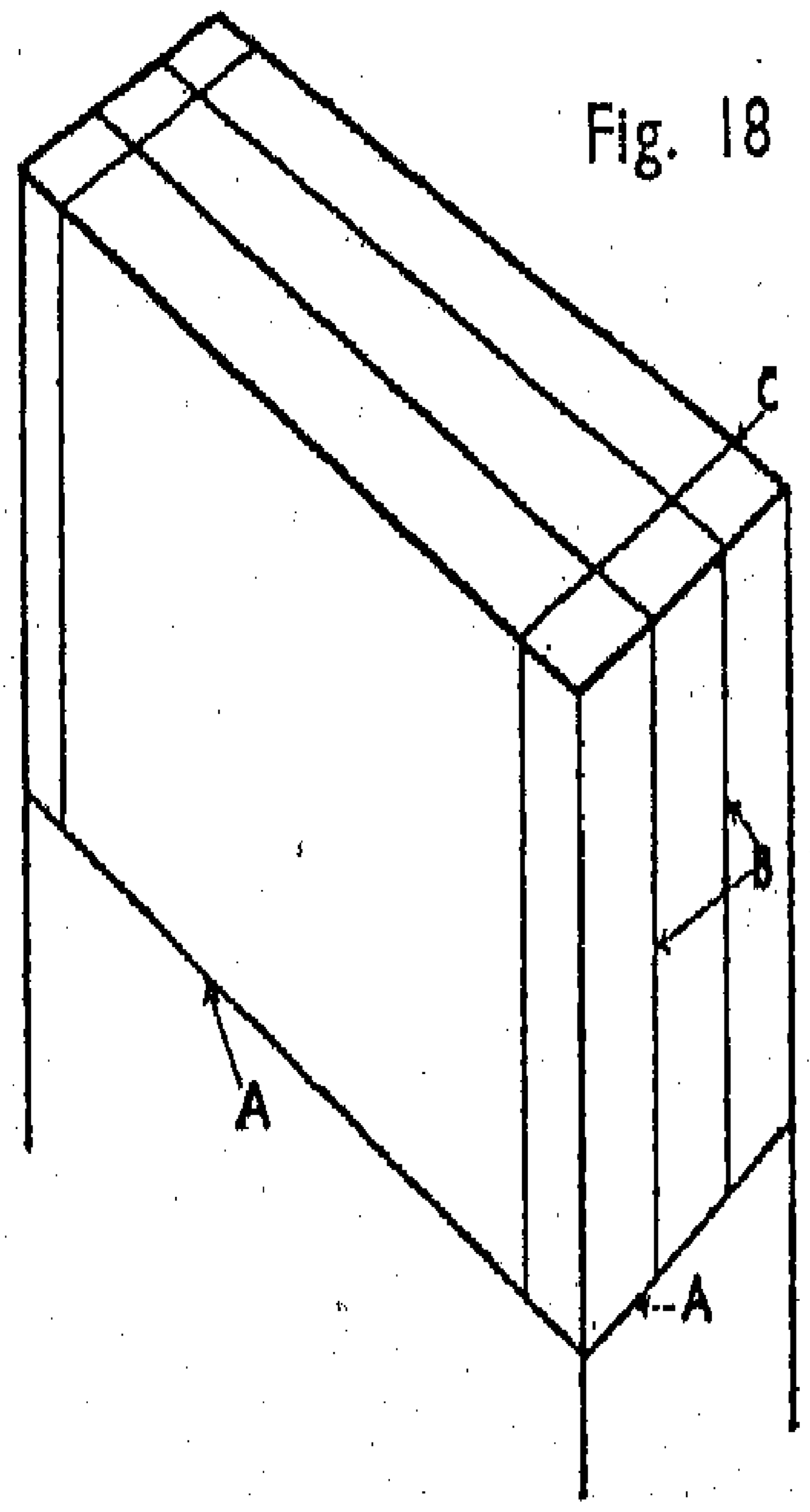


Fig. 18

For the purpose of describing the various operations for making a mortice and tenon joint it is assumed that a T-joint with a shouldered tenon is to be made.

Before going into details, however, it should be noted that a special tool called a mortice-gauge is necessary. This tool, already described elsewhere, is similar to an ordinary marking-gauge but has two marking points, one of which is adjustable to enable it to mark two lines at the same time.

Assuming that the pieces to be joined have been planed up perfectly true, the first thing to do is to mark the position for the tenon, which is usually made a little longer than the finished size. Scribe a line round the faces where the shoulder of the tenon or projecting piece is to be, as shown at A in Fig. 18, and then set the mortice-gauge. As the thickness of the tenon is generally made one-third of the width of the timber, choose a chisel—mortice or firmer—of the desired width, and use the width at the cutting-edge as a guide to measure the distance between the two points of the gauge. Estimate either by eye or by rule a similar distance between the body of the gauge and the point nearest to it. Test for accuracy by first making pricks in the wood with the points of the gauge and then applying the gauge to the other side of the wood. If necessary, alter the gauge until the prick-marks agree. Now run the gauge round the timber to mark the position of the tenon as shown at B in Fig. 18. Set the marking-gauge equal to the thickness of the tenon, and then mark the lines as indicated at C. Carefully saw away the two broad faces and then the narrow ones, keeping the saw on the outside of the gauge-marks. Fig. 19 shows the completed tenon.

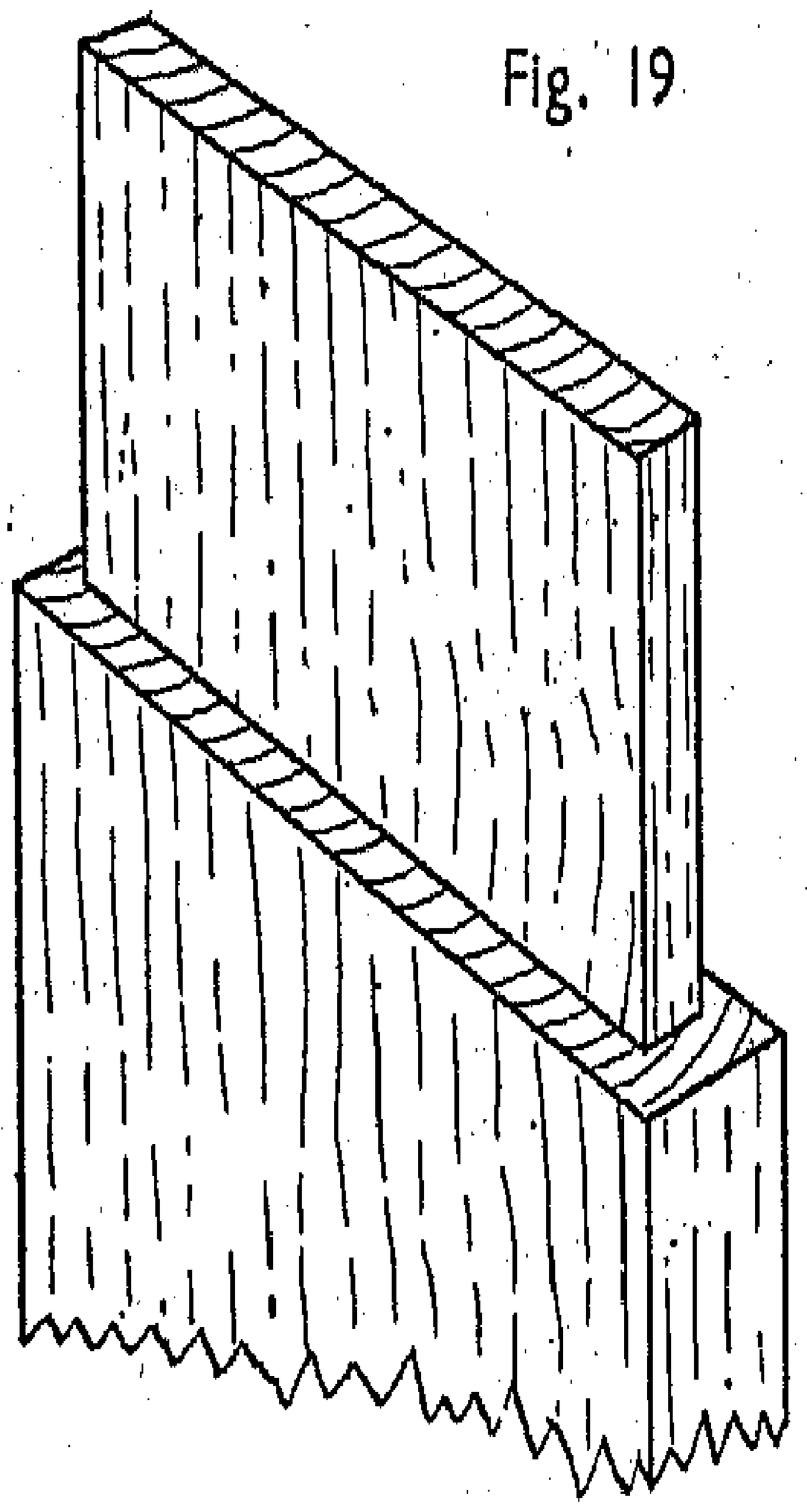


Fig. 19

Now lay the tenoned piece on its fellow member in the position it will eventually occupy. Make a pencil-mark on both sides, and then run the pencil round the face side and the two edges, using the square for the purpose. This indicates the position for the mortice. With the mortice-gauge, mark out from the face A the lines shown at B in Fig. 20, the actual position of the mortice on the two edges.

The next operation consists in removing the waste material. The simplest way to do this is first to remove the majority of the waste material with a brace and twist-bit and then remove the remainder and finish off with a firmer-chisel. Choose a suitable bit, that is, one that is a little less in diameter than the finished width of the mortice, and then bore a number of holes about half-way through the timber. The wood is then turned upside down and the same operation repeated from the other face of the mortice.

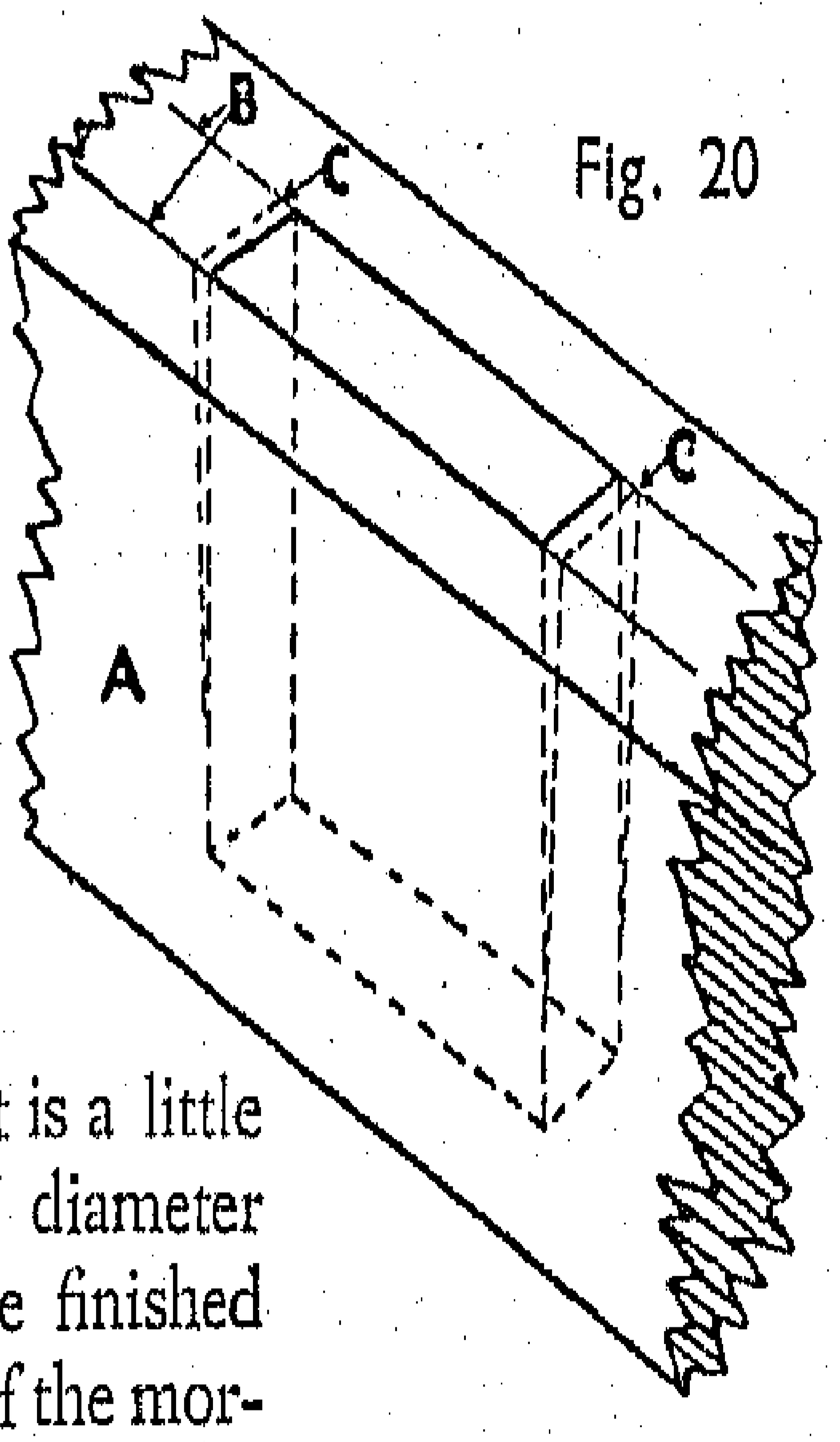


Fig. 20

When using the brace it is essential to keep the bit absolutely parallel with the sides of the wood in which the mortice is being cut, otherwise the work may be ruined. When this operation is completed all that is necessary is to remove carefully the remaining waste with a sharp chisel.

When an extra-strong joint is required, the two narrow edges of the outer face are cut away for about $\frac{1}{8}$ in., and the walls of the slot cut downwards in a slanting direction to take two wedges, as shown by the outside dotted lines at C in Fig. 20. Such a joint is known as a keyed-through tenon. The wedges should be made to the same width as that of the aperture.

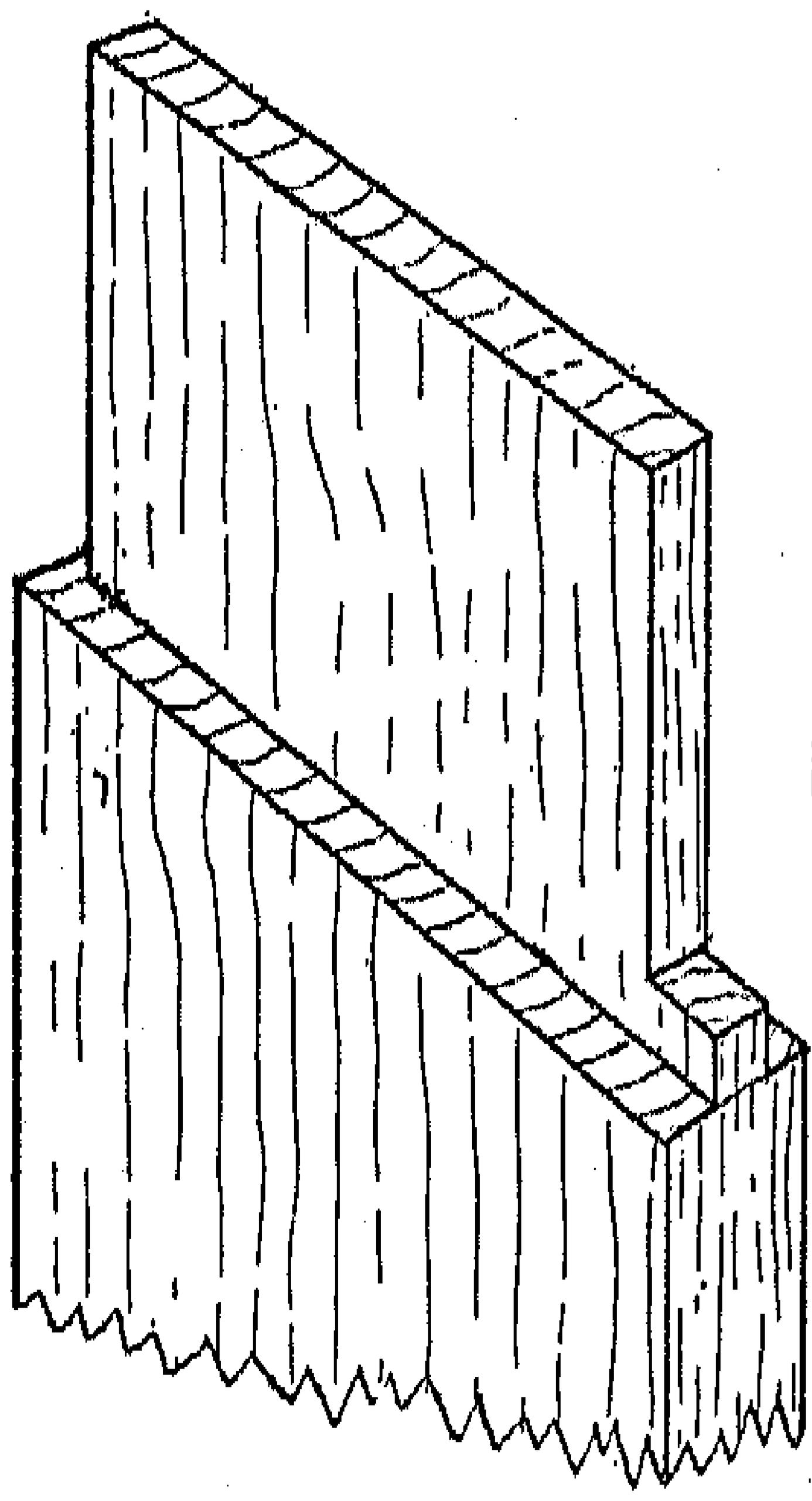


Fig. 21

The joint is complete when a small quantity of glue has been brushed in the mortice and on the tenon, and the tenon either pushed or knocked into the mortice. If wedges are used, a spot of glue should be applied to each wedge before driving them home. As you do this, test for squareness, as one of the wedges may force the joint slightly out of truth. This fault can be corrected in most instances by driving in the other wedge before the glue sets. When sufficient time has elapsed to allow the glue to set thoroughly, the tops of the wedges and the tenon are sawn off flush, and the surfaces trimmed up with a plane.

Haunched Tenon.—Fig. 21 illustrates a square haunched tenon used in cases where the end of a morticed piece has to be flush with the tenoned member, instances of which are found in the joint connecting the top framing to a table leg, and the framing of a large panelled door.

The tenon is formed in a similar way to the plain tenon except that one end-piece is cut away as shown clearly in the illustration. The mortice is made to take the haunch which, of course, is shorter than the actual width of the tenon.

Stopped Tenon.—A tenon that does not pass right through the morticed member is called a stopped tenon or a stub tenon, an example of which appears in Fig. 22. The pieces are marked and cut out as previously described, except that the mortice is cut to a sufficient depth to suit the length of the tenon.

Where two stopped tenons meet in the timber, for example, where the sides of the frame meet at right angles at the tops of table legs, the ends of the tenons are mitred off as indicated in Fig. 23. The mitre gives a longer bearing and a larger gluing surface, which imparts additional strength to the joint.

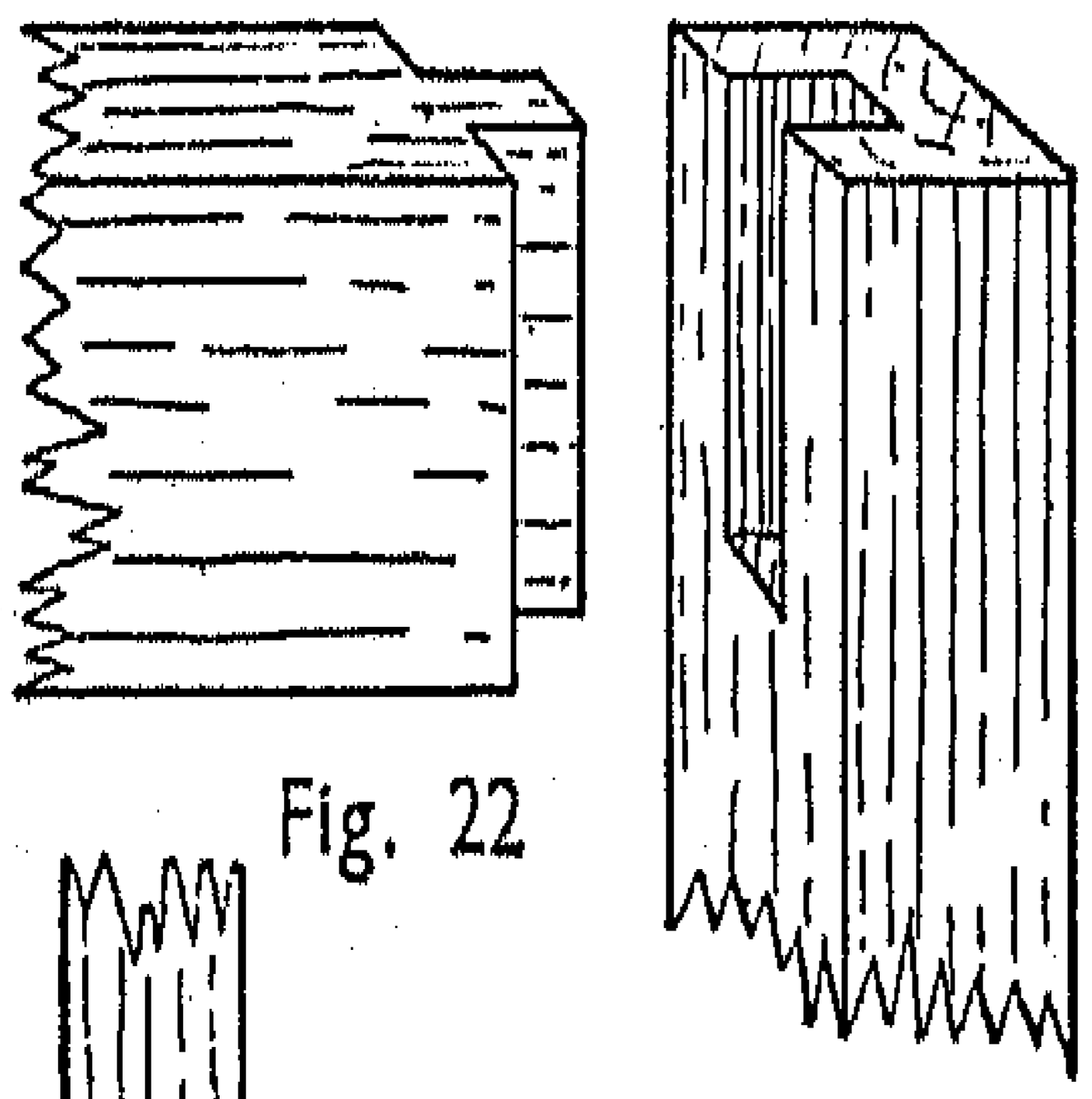


Fig. 22

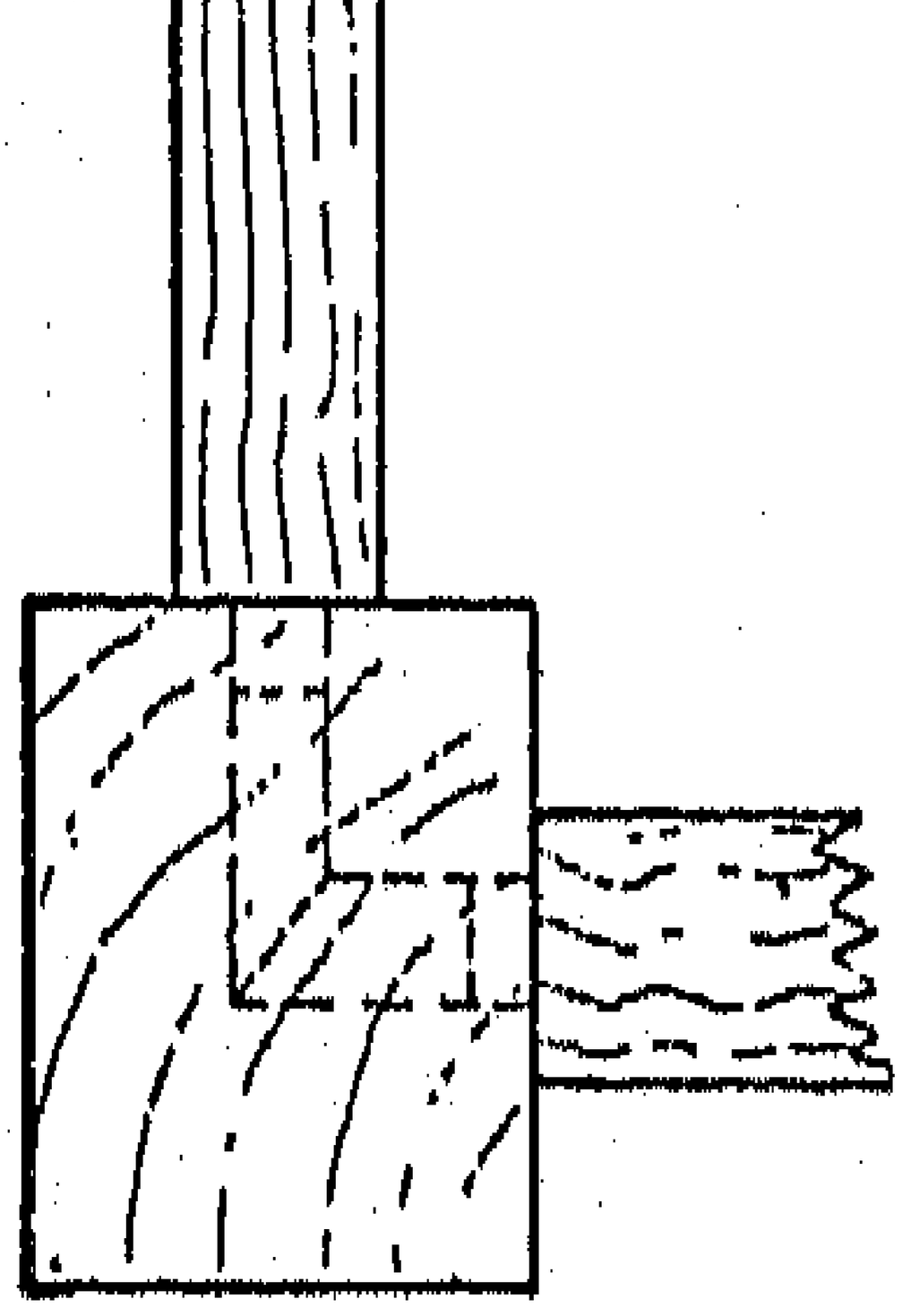


Fig. 23

Barefaced Tenon.—The barefaced tenon has only one shoulder and is used in cases where the interior of the framework, such as matchboards, is required to lie flush on the face side in the manner shown in Fig. 24.

The thickness of the rails or cross-pieces is determined by the thickness of the material used between the uprights or stiles.

The members are marked with the aid of a single-pointed marking-gauge and cut out in the usual way.

As previously pointed out, a successful joint depends upon the accuracy of marking out and cutting. Great care should be taken to see that these conditions are complied with. Most faults arise through want of system and forethought, and hurrying to get the job finished. In cutting, the saw may be guided with the finger-tips of the left hand or by the use of a straight-edged strip of wood placed with its edge along the gauged lines. In marking out, use a knife in preference to a pencil—except, of course, in special cases—as its use tends to greater accuracy, and the marks do not get obliterated. As there is a tendency to cut in a slight curve, even with a tenon-saw, the curvature can be rectified with a chisel.

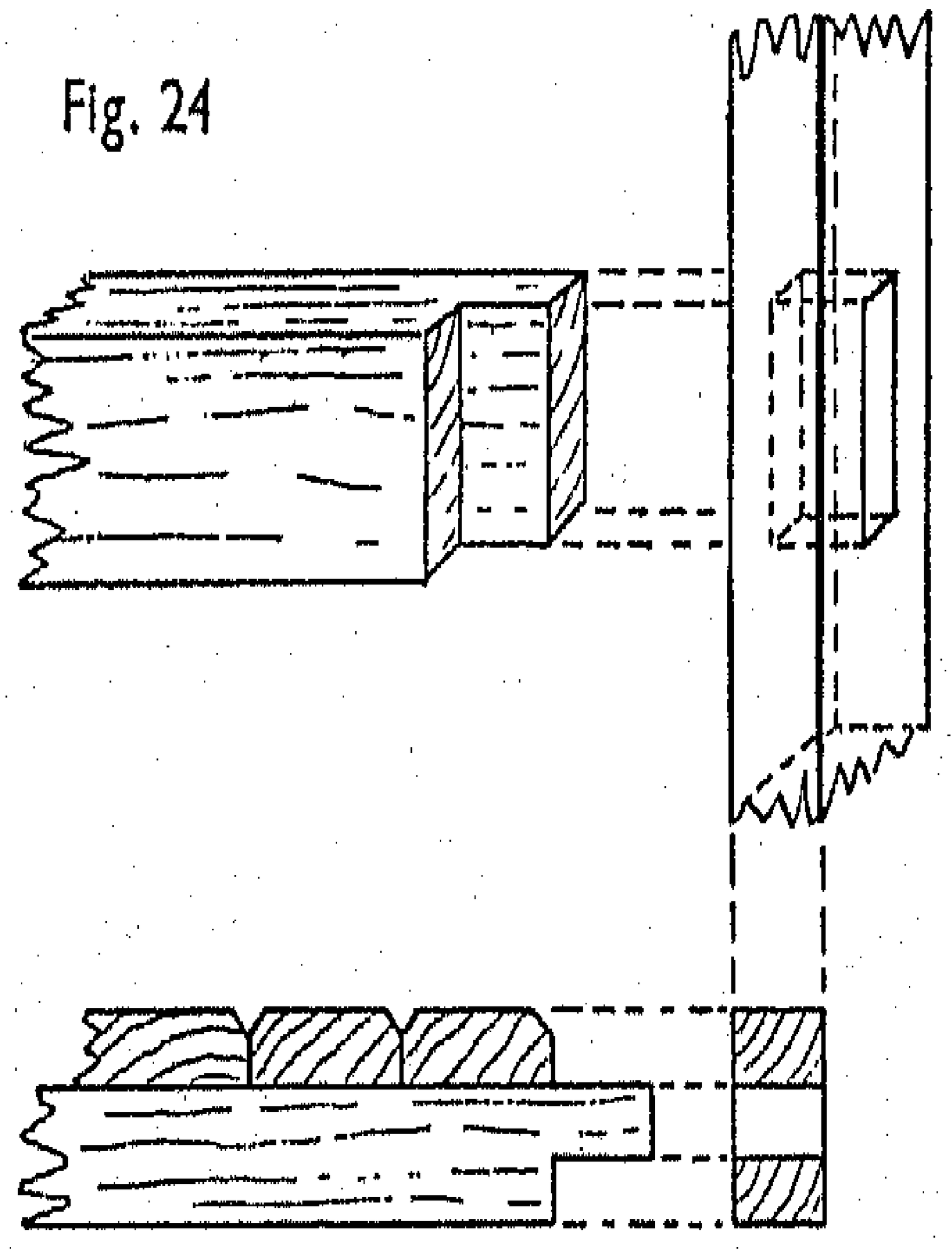


Fig. 24

A good-fitting joint can be obtained by cutting the shoulders of the tenon a little out of square, as shown in Fig. 25.

Housing Joint.—Fig. 26 shows two types of useful joints known as housing joints. That shown at A illustrates through housing and that at B is called stopped housing. It is used extensively in fitting shelves, etc., into their uprights. The joint is formed by sinking the ends of the shelf, for instance, into grooves cut in the uprights for their reception. The depth of the groove is usually one-third of the thickness of the wood.

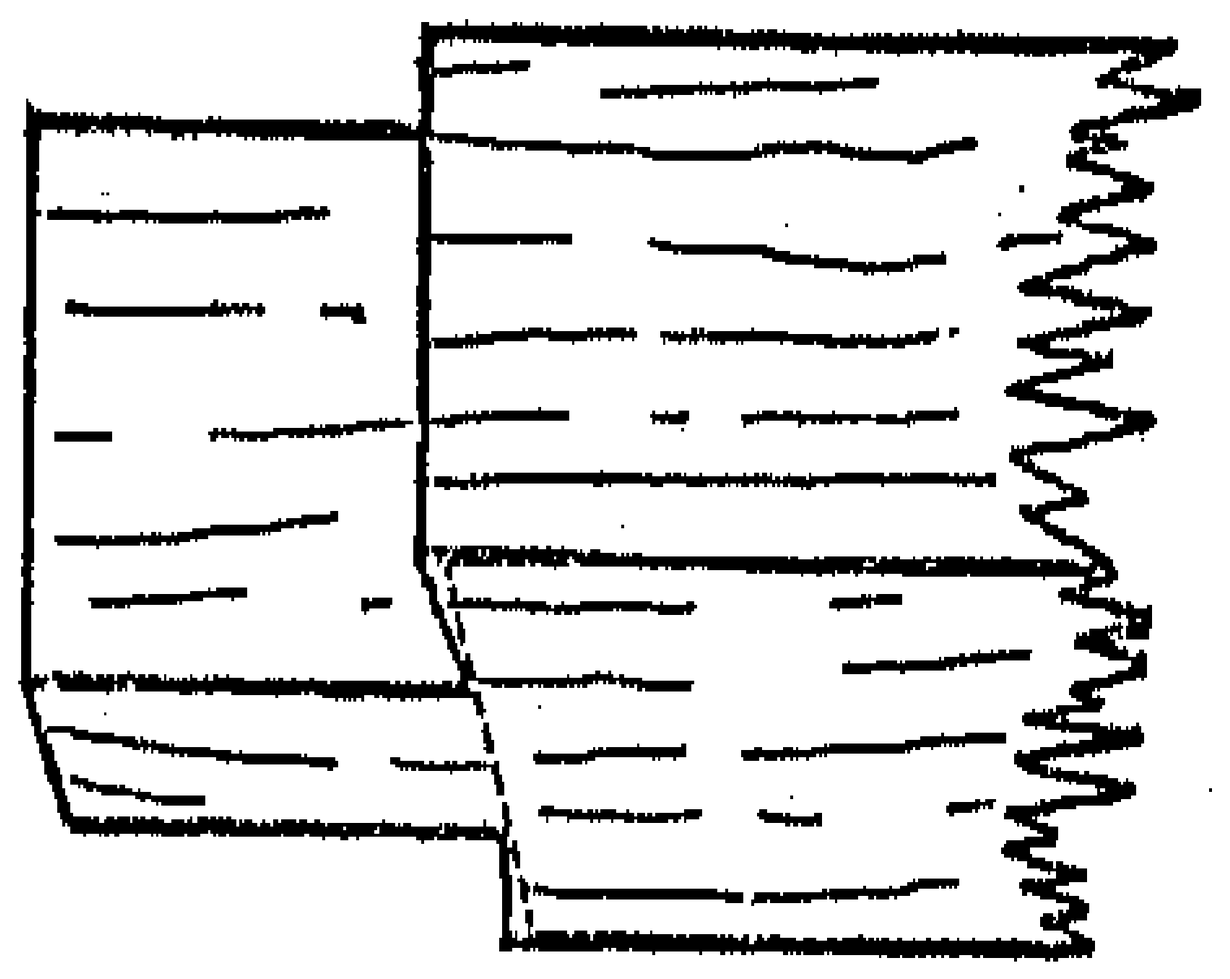


Fig. 25

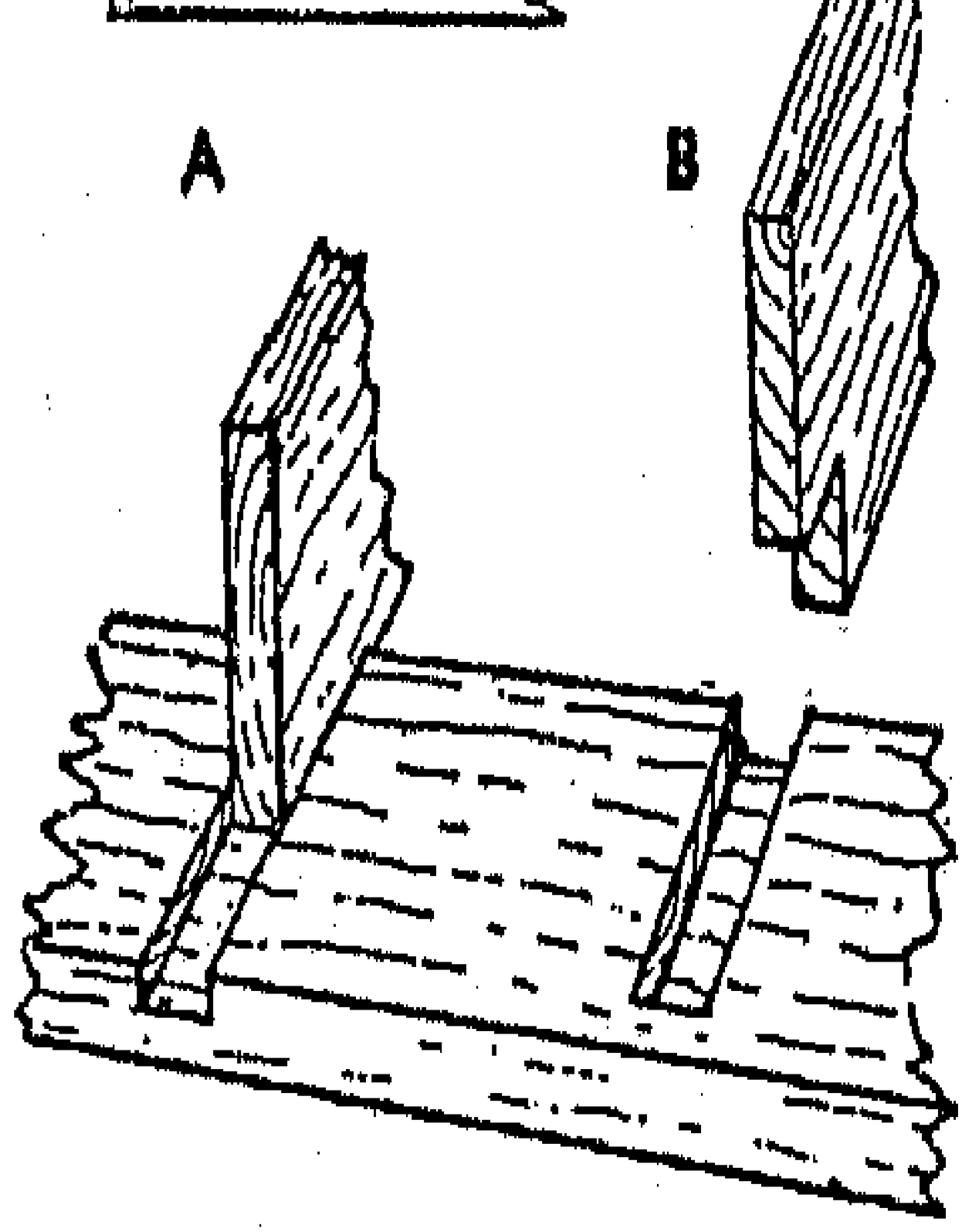


Fig. 26

To make the through joint, first true up the wood and then mark the width and depth of the groove in the piece to be recessed, using a square for the purpose. The width of the groove is equal to the thickness of the shelf or board to be joined. Cut across the lines so marked down to the depth-marks with a tenon-saw, not forgetting to saw in the waste. The waste can then be roughly removed with a chisel and finished off with a router-plane.

When using the chisel, work from one edge to the centre, then turn the wood round and work from the other edge towards the centre.

In making the stopped housed joint,

the trench is stopped a short distance from the edge of the upright.

Square and mark out in the same way as previously mentioned, not forgetting to gauge the length of the stopped end. Cut across the lines with the saw held slantwise, that is, handle down, until the saw reaches the stop and is the correct depth at the other end. Remove the waste with a chisel and finish off with a router.

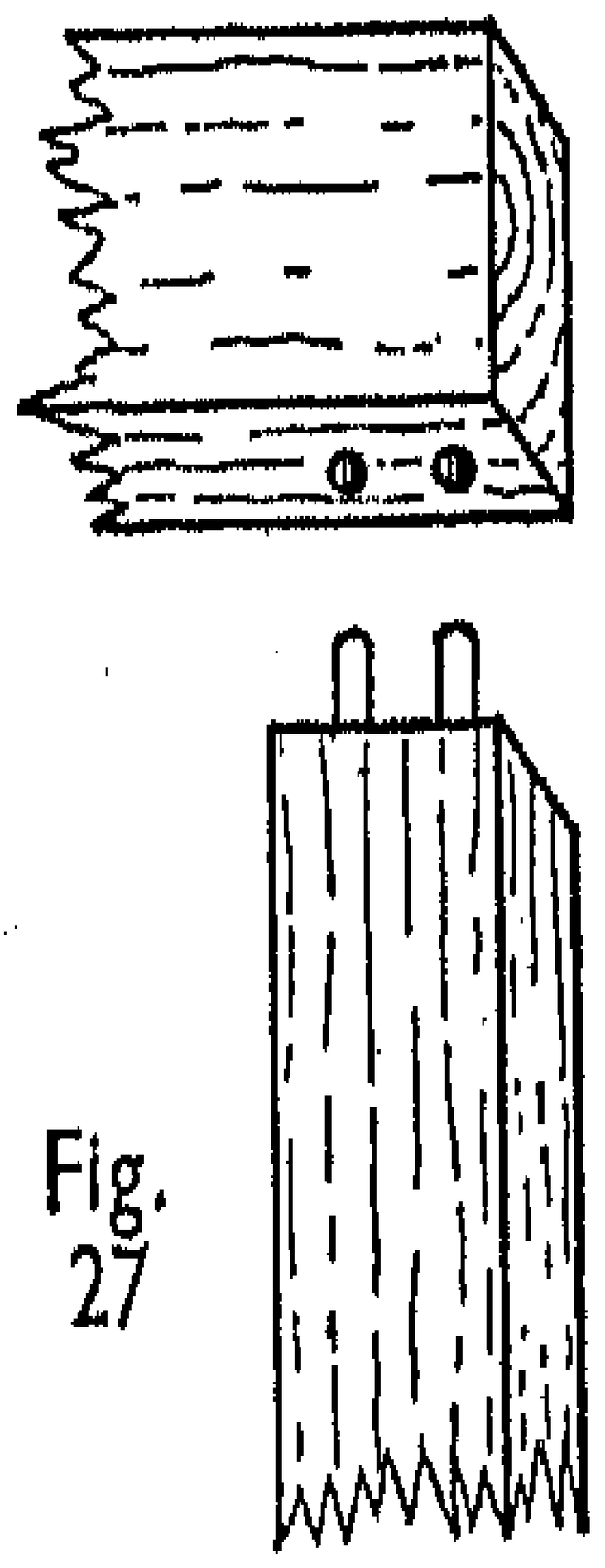


Fig. 27

Dowelled Joint.—The dowelled joint is useful for numerous purposes, the chief of which, perhaps, is that for joining two or more boards together widthways, as shown previously in Fig. 4, and for making simple right-angled joints, as illustrated in Fig. 27.

The joint consists of a series of dowels or hardwood pegs glued into holes bored at right-angles to the surfaces to be joined. The dowels fit into corresponding holes bored in the other member.

The dowel is made of hardwood such as beech, and can be bought ready-made in various diameters from $\frac{1}{8}$ in. upwards, in lengths of about 3 ft.

The parts to be joined are prepared in the same way as the glued butt joint, and the holes to be bored are marked with square and gauge. A twist-bit of the same diameter as that of the dowel is used for drilling the holes. Fig. 28 shows the two members marked ready for boring.

Before boring the holes it is advisable to centre-punch each centre-mark to ensure even entry of the bit. Drill the holes to the desired depth, which will depend upon the size of the dowel used, taking care to keep the bit upright when boring, otherwise an unsatisfactory joint will result.

Having completed the holes, countersink the tops to remove the sharp edges. Cut the dowel-pins to the correct length, and make a slot or groove in them, as shown in Fig. 29, to allow the surplus glue to escape. This may be done by holding the pin in the vice and sawing a small channel along the length of the pin. Remove the sharp edges at the ends by rubbing them with glass-paper.

The joint is made by first gluing the pins and driving them into the holes of one board, gluing the edges of both, including the pins, and then knocking the parts into place by means of a mallet. As the edges cannot be rubbed together to extrude the surplus glue, it is a wise plan to use cramps. If the work is such a size that it prevents the use of ordinary cramps, the difficulty may be overcome by laying the work flat on the floor with one edge against a wall and the other edge wedged against a length of batten nailed to the floor. If this method does not answer the purpose, the worker must use his ingenuity as to the best way of overcoming the difficulty.

Fig. 28

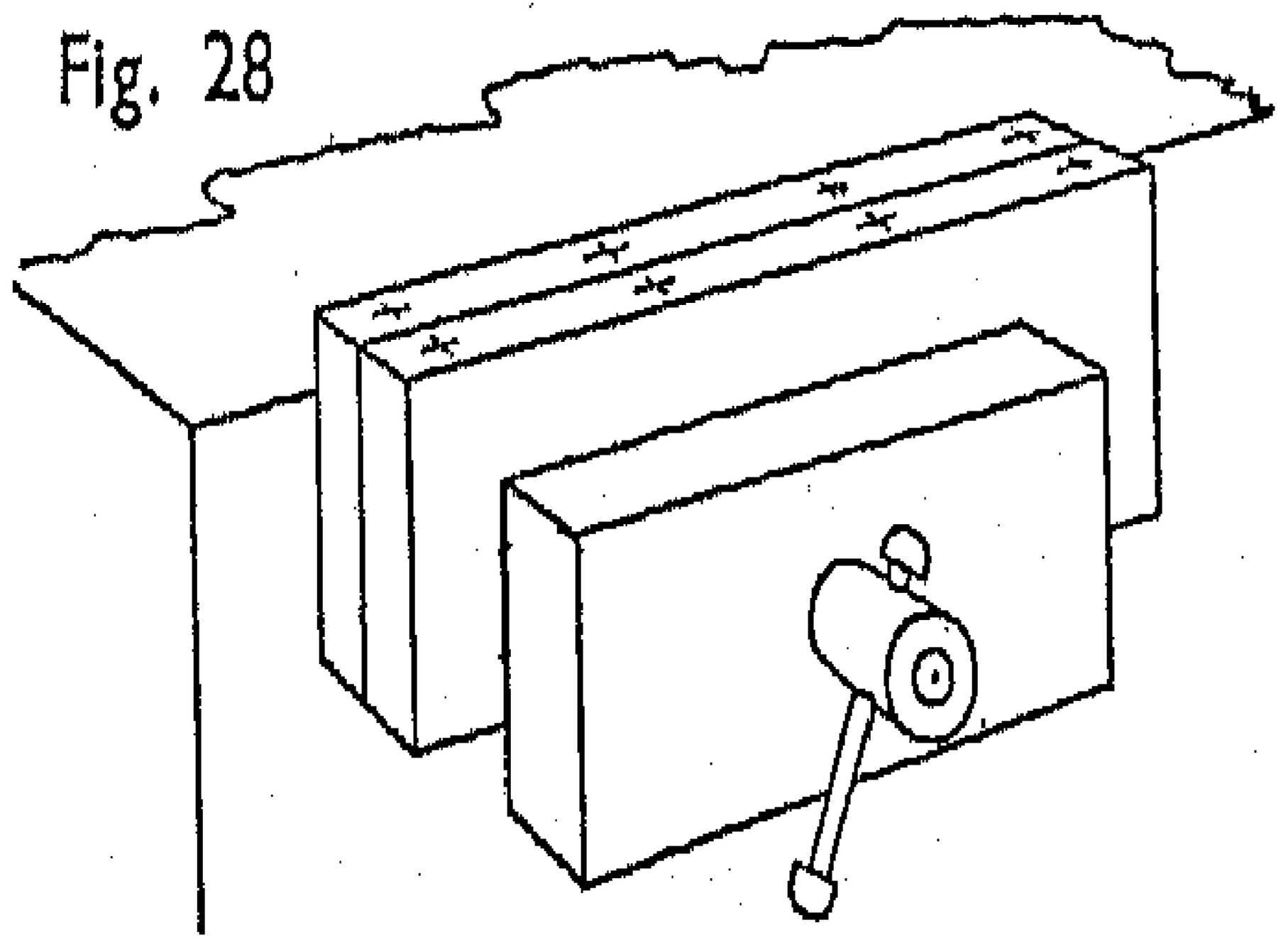
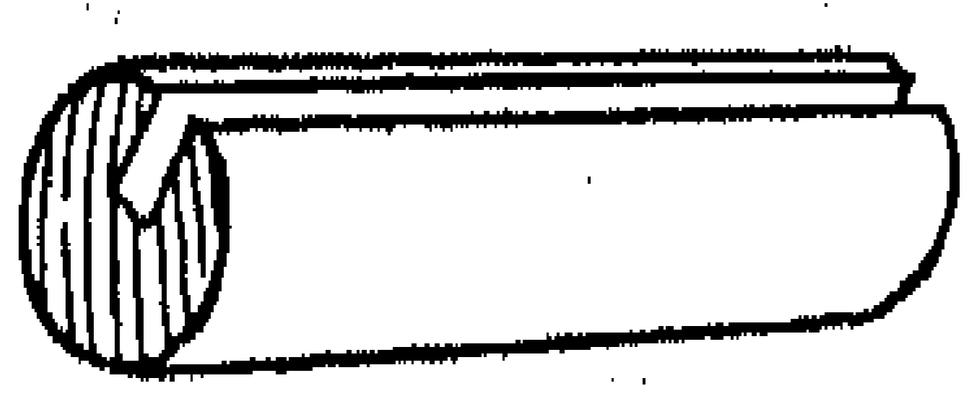


Fig. 29



It may be mentioned that whenever it is found necessary to use a hammer or a mallet on the edges of work, a piece of waste wood should always be inserted between the work and the striking-tool to prevent bruised and damaged edges.

An improvised dowelled joint can be made by using nails and screws in place of wooden pins.

The work is prepared and marked as previously explained, and wire nails, oval brads, or screws are partially driven into the edge at equidistant spaces in one member. The heads of the "dowels" are then removed, and the projecting parts filed to a chisel-edge, care being taken not to loosen the pins. After the edges of the boards have been glued they are knocked into place and cramped. To facilitate the entry of the metal dowels, a number of holes should be drilled, in positions corresponding with those of the pins, in the edges of the board to be joined, using a bradawl a trifle smaller in diameter than that of the pins.

Another effective method of strengthening a glued butt joint is to drive a number of screws into the edge of one board, as indicated in Fig. 30, allowing the heads to project a trifle above the surface. Holes are bored at a distance of about $\frac{1}{4}$ in. in front of their actual final positions in the piece to be joined to take the heads of the screws. Narrow channels about $\frac{1}{4}$ in. in length are then cut in the second board, just wide enough to take the smooth shanks of the screws. After gluing, this board is so placed that the screw-heads enter the holes in the other piece, and is then driven on from the end until it assumes its correct position. The heads of the screws tend to work upwards as they cut channels for themselves and thus tighten the joint.

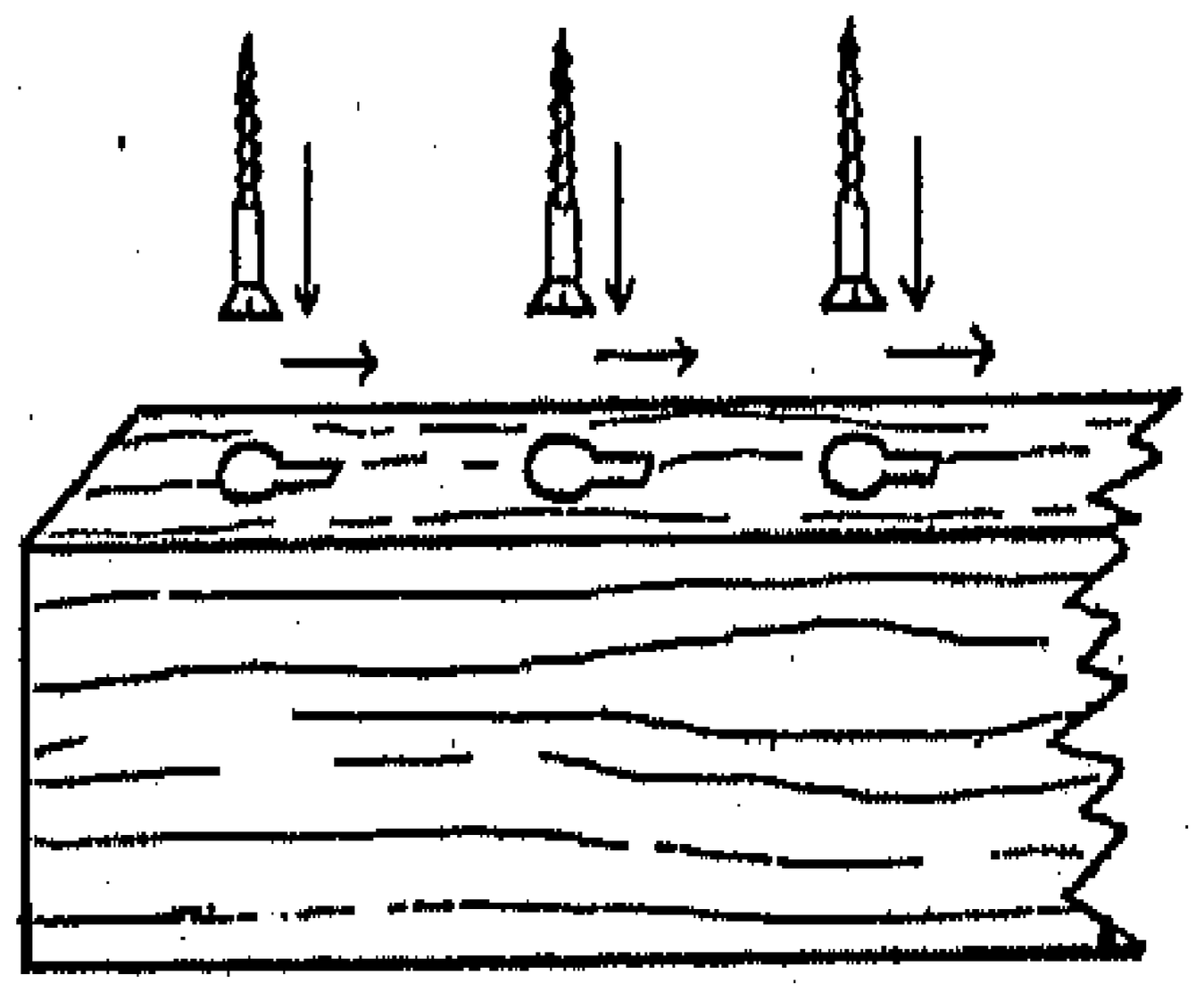


Fig. 30

The Dovetail Joint.—The dovetail joint is not a difficult joint to make, but the greatest care is needed in marking out and cutting. It consists essentially of one or more inverted wedge-shaped pins fitting into similarly shaped sockets which lock the joint.

Single dovetail joints are used mostly in joinery, and multiple dovetailing is resorted to in cabinet-making, in the construction of drawers, etc.

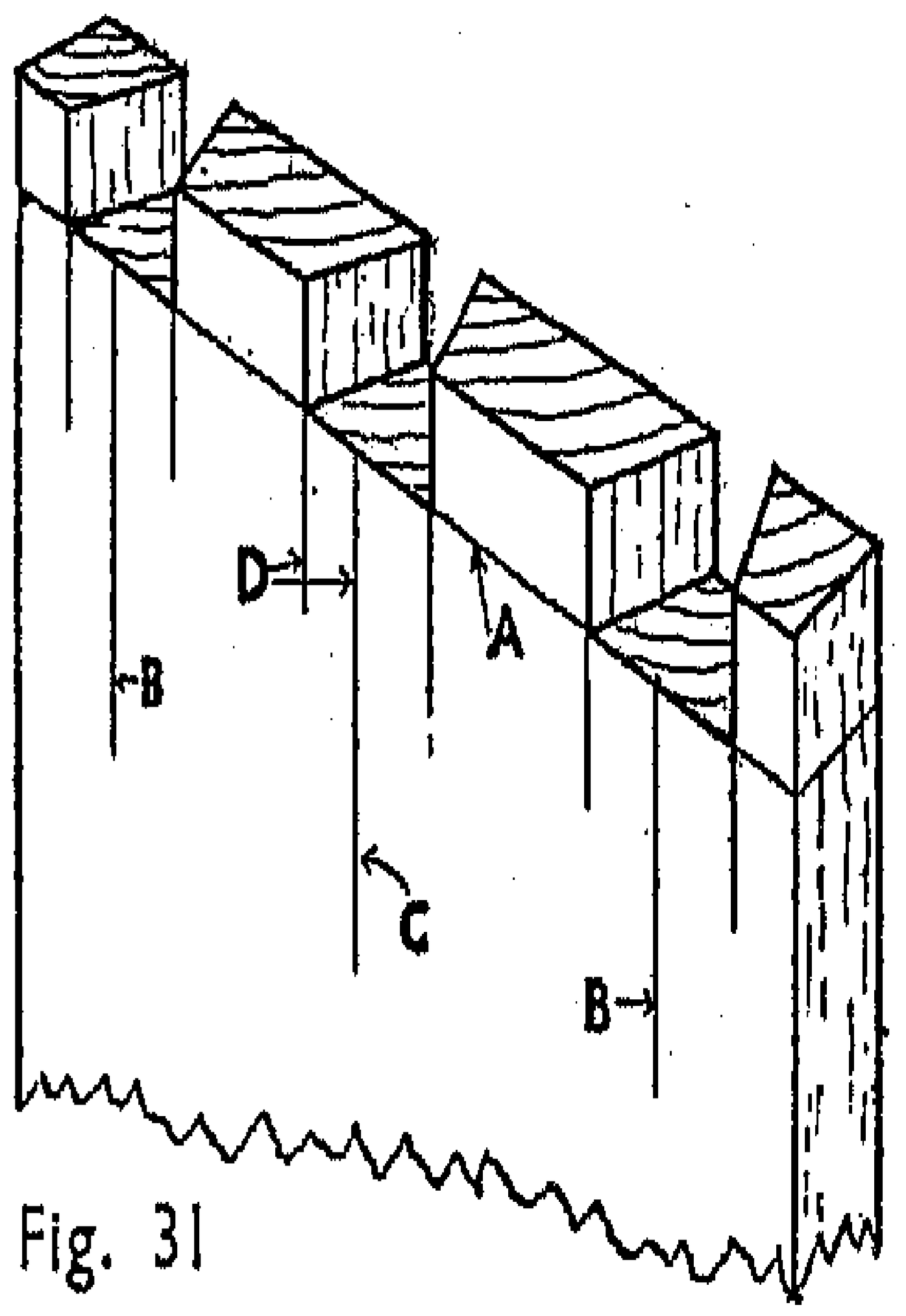


Fig. 31

The joint should be made just hand-tight, otherwise the angles of the pins and their sockets as well as the outer dovetails are likely to be broken off.

For the purpose of explaining the process of making a simple dovetail joint it is assumed that the front, back and sides of a box are to be prepared for dovetailing after the parts have been trued and the ends properly squared.

The pins are formed on the sides and the sockets on the front and back of the box. Start by marking out the sockets. As the two pieces are identical they can be marked at the same time by fastening them together with fine brads. Great care must be taken when doing this to see that the edges are flush.

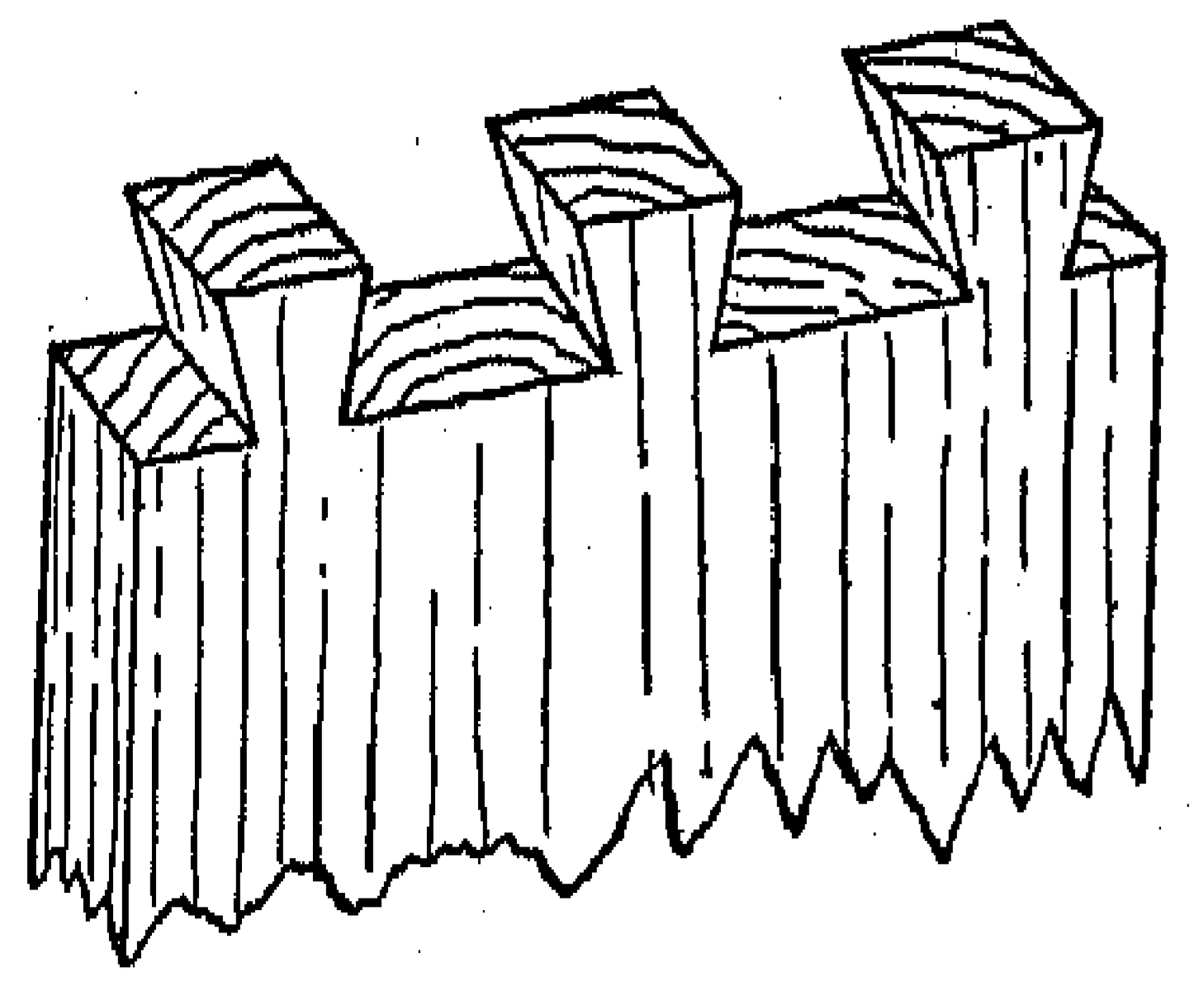
Place these parts in the vice, working-end up, and measure the thickness of one piece. Scribe a shoulder line right round the work at a distance from the top edge equal to the thickness of the piece just measured. This is shown at A in Fig. 31.

The number of dovetails required in a given length is an arbitrary matter, although it is usual to have a larger number when hardwood is employed. It will be assumed that three pins and sockets are desired.

Mark off a distance equal to the full width of a socket at each end of the shoulder line, indicated by B in the illustration, and divide the space between these points into two, which gives the centre of the middle socket. Mark this point, as shown at C. From each of these centres, mark on both sides half the width of a socket. These lines are shown at D. For example, if the extreme width of the socket is 1 in., the distance to be marked on each side of the centres is obviously ½ in. Now set the bevel to an angle of 10°—the angle must not be too acute, otherwise the joint will be weak—and mark the inclined lines by placing the stock of the bevel on the top edge of the work. Square the lines across the top and mark the angles on the back face.

The next operation consists in cutting the sockets down to the shoulder line by means of a dovetail-saw or, failing this, a fine-toothed tenon-saw. When sawing, great care must be exercised to keep the tool on the waste side of the guide lines.

Fig. 32



To facilitate the next operation, which consists in removing the waste, it is an advantage to make a number of saw-kerfs in the waste down to the shoulder line before chiselling out.

When both ends have been cut, remove the work from the vice, and separate the pieces.

The waste is cut out with the aid of a very sharp chisel by first working from the top face, then reversing the work, and finishing off on the other side. When doing this, place the work on a piece of waste wood to prevent damage to the top of the bench.

The positions of the pins to be formed on the back and front of the box may now be marked from a socketed member, in the following manner.

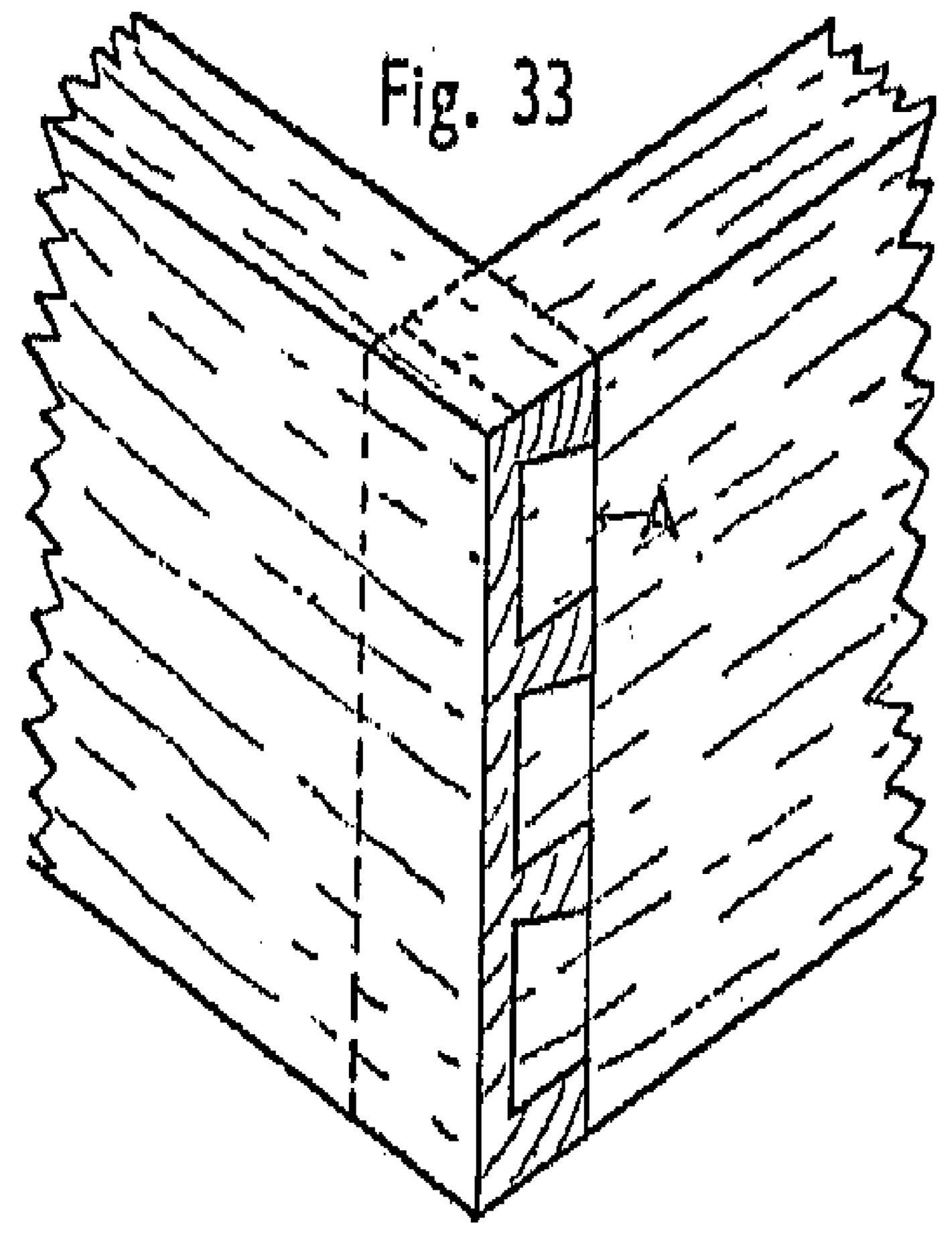


Fig. 33

Lay the piece to be marked flat on the bench, and place a socketed piece on edge on top, so that it forms a right angle, taking care to keep the face of the socketed member flush with the edge of the other. Now mark out the angles by using the inside edges of the sockets as guides, using a finely-pointed pencil for the purpose. The remainder of the marking out is then completed in the same way as that adopted in marking the sockets.

The sawing and removal of the waste is then carried out in the same way as already explained.

An illustration of the finished pins appears in Fig. 32.

Fig. 33 illustrates a blind or lap dovetail, so called because the pins do not show on the face. It is used to a large extent in making drawer-fronts where the appearance of the ends of the pins would look unsightly.

In making a drawer-front it is usual to have this part thicker than the sides and back, and to make the pins first. The length and width of the pins should be equal to the thickness of the sides.

To mark out the pins, set the marking-gauge to the thickness of the sides, and make a shoulder line on the inside face. Next, mark a line along the edge without altering the gauge, near the outside face, as shown at A in Fig. 33. Now set out the pins by marking off half the thickness of a pin from each end of the shoulder line and mark the centres for the pins in the intervening space by using either the dividers or rule. Set out the bevels as previously described.

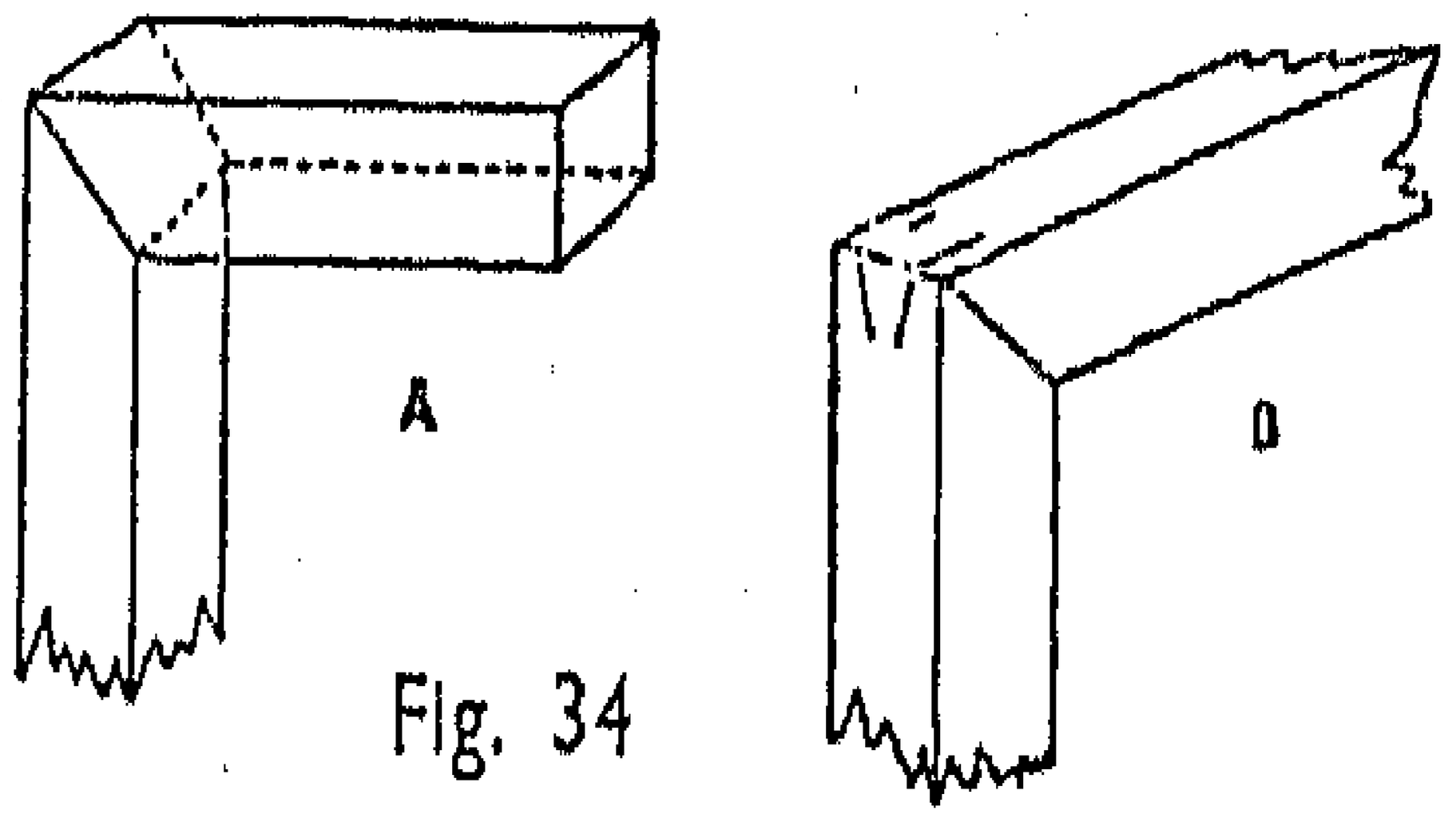


Fig. 34

The removal of the waste calls for careful work. Cut away as much waste as possible with the dovetail saw held at an angle, and clear out the remaining wood with a very sharp chisel.

Shoulder lines are now scribed on the ends of the side pieces, and then marked from the pins.

Mitre Joint.—The mitre joint, shown at A in Fig. 34, is commonly employed in picture-framing for joining the horizontal and vertical members.

The joint is made by first marking out the ends at an angle of 45°, planing them up true on the shooting-board, and then gluing the parts together.

A stronger joint than the plain mitre, used principally in cabinet-making and joinery, is obtained by the insertion of tongues or keys at the corners as shown at B in Fig. 34.

To make such a joint, mark and plane the mitred surfaces accurately and glue up as in the plain mitre. When the glue is set, place the work in a vice and make two saw-kerfs across the corners with the saw held at an angle to form a dovetail, as shown clearly in the illustration. Insert a thin piece of glued hardwood with its grain at right-angles to the joint, into each slot, and allow the glue to dry. The ends of the hardwood pieces are then trimmed off flush.

End Lap Joint.—A joint commonly used for a quick, cheap job where accuracy and neat appearance are of little importance, is the end lap joint shown in Fig. 35. It is used principally for making packing-cases and boxes.

The wood is cut to lengths and either nailed or screwed at the sides. If nails are used, a better hold is obtained by driving them in slantwise, as indicated in the sketch. The bottom member is fixed after the sides have been assembled.

A modified joint of this type is shown in Fig. 36. Such a joint is useful when constructing common-type drawers, where a dovetailed joint is not deemed advisable. A rebate is formed on the inside face at each end of the front piece

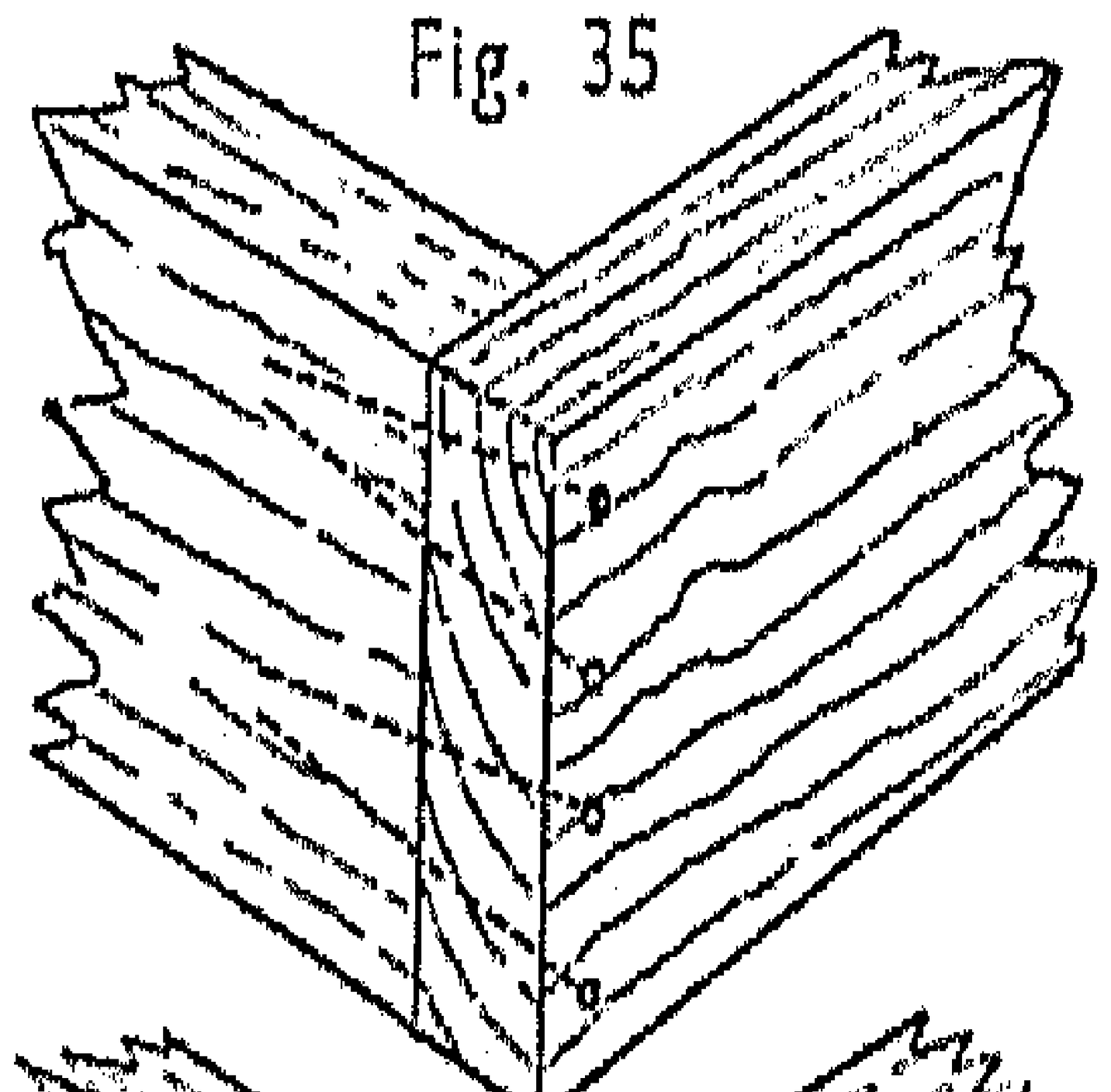


Fig. 35

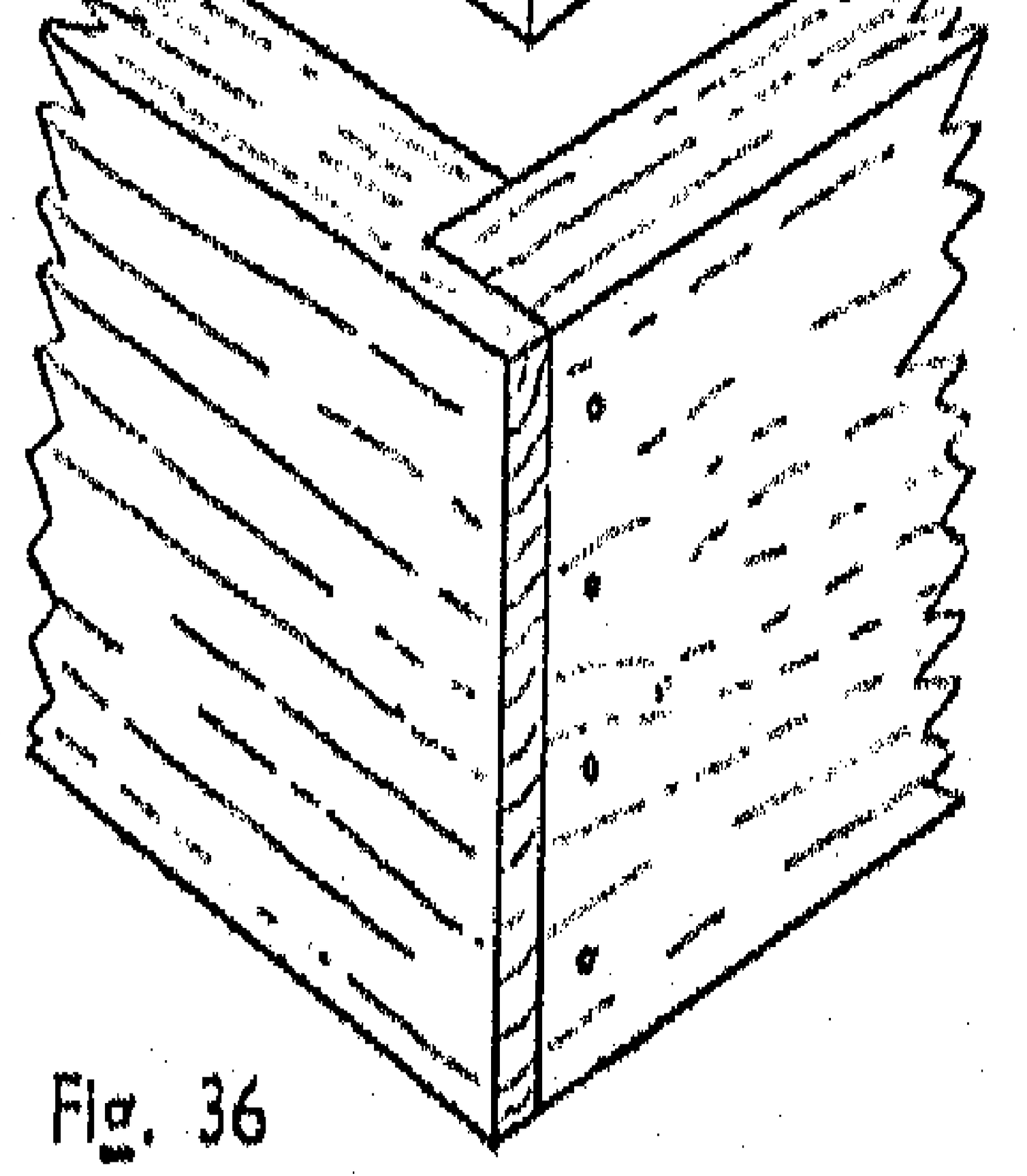


Fig. 36

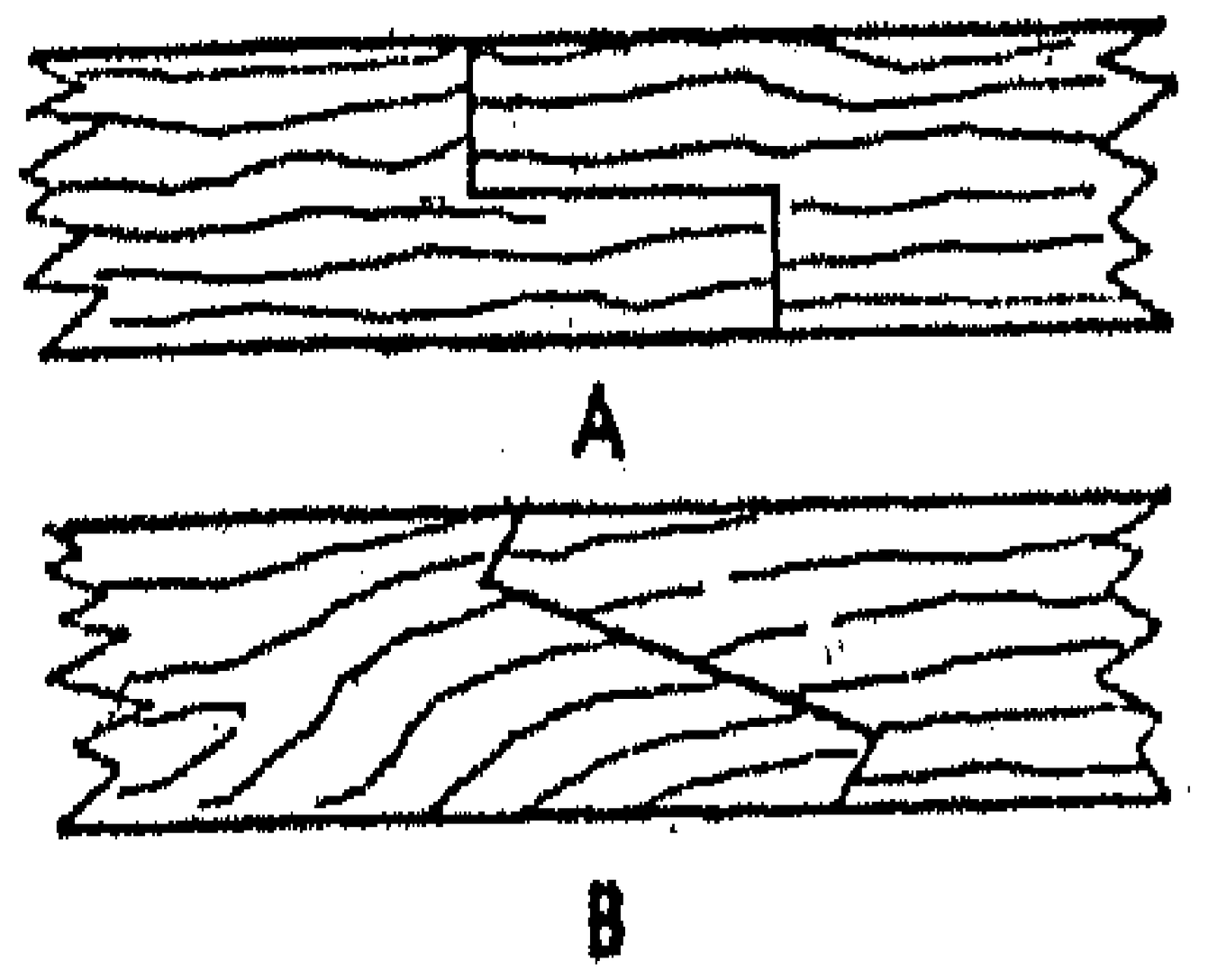


Fig. 37

to take the sides, which are fastened by glue and secured by nails or screws.

Lengthening Joints.—Joints for lengthening timber are used mostly in large constructional work, and therefore seldom attempted by the amateur.

Two typical examples of such joints are illustrated in Fig. 37. That shown at A represents a halved joint, and that at B, a scarfed joint. In both joints the members are usually bolted together.

HINGES AND LOCKS

Hingeing is the process of connecting two or more pieces of wood together in such a way as to allow one to revolve or move about the other. The connecting part that allows this free movement is called a "hinge."

There are many different kinds of hinges, each designed for a particular purpose. These include butt hinges, flap hinges, T-hinges—some plain and some ornamental—and others too numerous to mention.

The Simplest Form of Hinge consists of a strip of leather fastened to the faces of the stationary and moving parts. Although somewhat primitive, a leather hinge is remarkably durable and useful at times for hanging doors to poultry houses and similar objects.

Where such material is used, it is better to use round-headed screws in preference to nails for fixing purposes. Metal washers should be inserted between the head of the screw and the leather to prevent the screw-head tearing the material. If nailing is desired, it is a good plan to use galvanised clout nails as they have large heads and the galvanising coat prevents rust.

Another useful and simple type of hinge is found in the ordinary clothes-horse, in the form of pieces of cloth webbing fitted at the top and bottom of the members, allowing the sections to be folded in both directions. These hinges are usually fixed by means of short galvanised clout nails for the reason stated above.

Metal Hinges.—Fig. 1 shows a few common types used for woodwork. The one shown at A is known as a "butt," and is a comparatively heavy hinge usually made of iron for common work and brass for furniture and cabinets. It is long compared with its width, and can be obtained in sizes ranging from ⅜ in. to about 3 in.

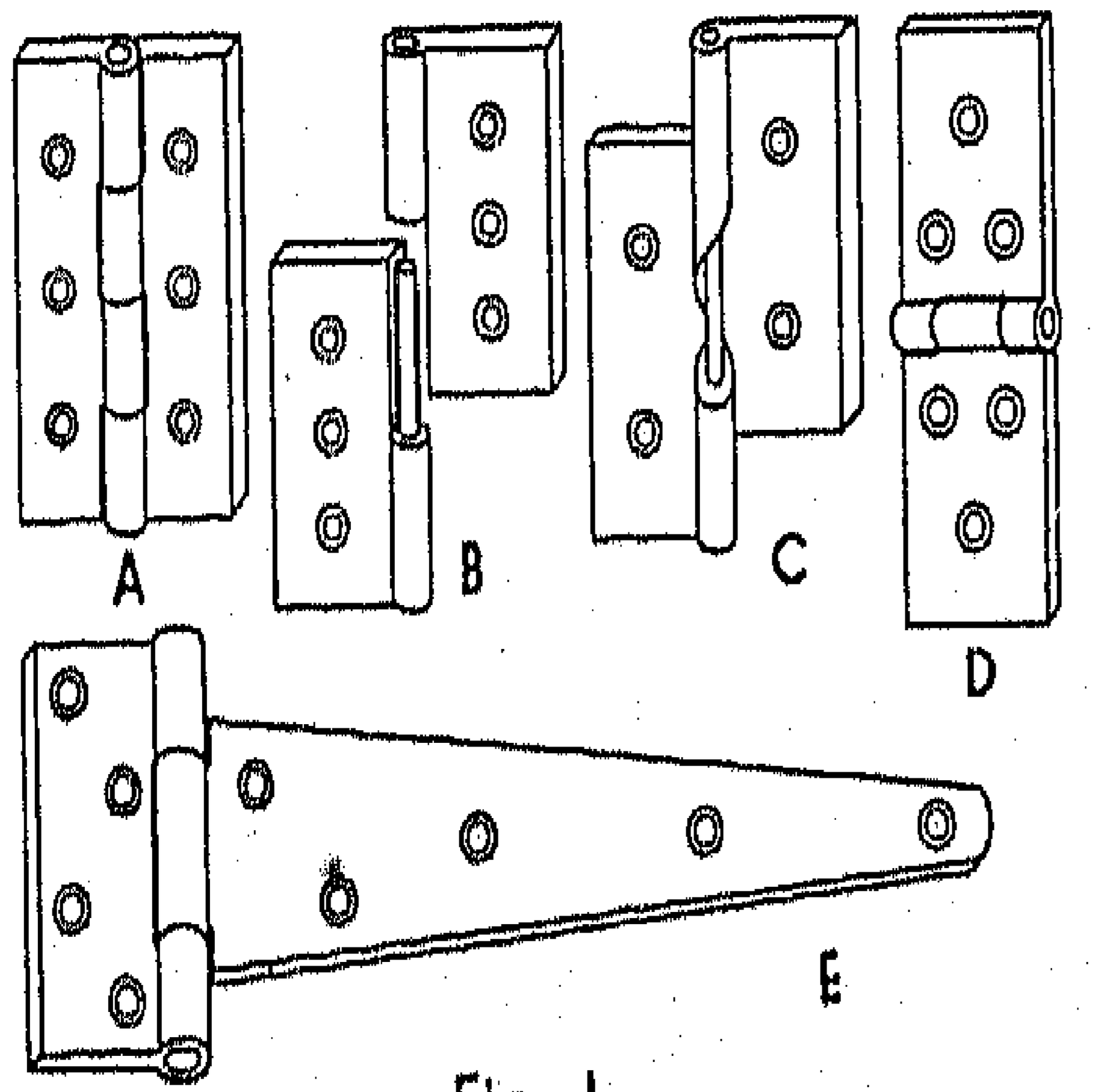


Fig. 1

Another handy form of a butt hinge, known as a loose butt, is illustrated at B. The chief difference between the ordinary butt and the loose one is that the former has the two leaves forming the hinge locked together by the central pin, whereas one leaf of the latter can be removed from its fellow member. This useful feature enables a door, for instance, to be easily removed.

The Rising Butt Hinge illustrated at C has a loose leaf, which, when opened, rises on the centre pin and thus enables a door on opening to rise over a mat or a thick carpet and to close automatically.

The Back-flap Hinge represented at D is longer than its width, and can be obtained in either mild steel or brass. Such a hinge will often be found more useful than the butt type for certain amateur purposes, as it generally takes less cutting away to fit.

An extremely useful type of hinge, known as a T-hinge or cross-garnet, is depicted at E. This type of hinge is largely used on shed doors and garden gates, etc. where appearance is not the primary consideration. Cross-garnets require no great amount of skill to fix as they are generally fastened to the surface of the wood by countersunk-headed wood-screws.

Where cross-garnets are used on a shed door having a lock and key, one or two plain, round-headed bolts and nuts should be employed in place of ordinary wood-screws. The bolts should be fitted with their heads on the exterior of the door and secured by nuts on the inside. The screw-holes in the hinges may have to be enlarged for the purpose, in which case the tang end of a file can be used for reamering out the surplus metal. This will prevent unauthorised persons gaining access to the interior of the shed by removing the screws.

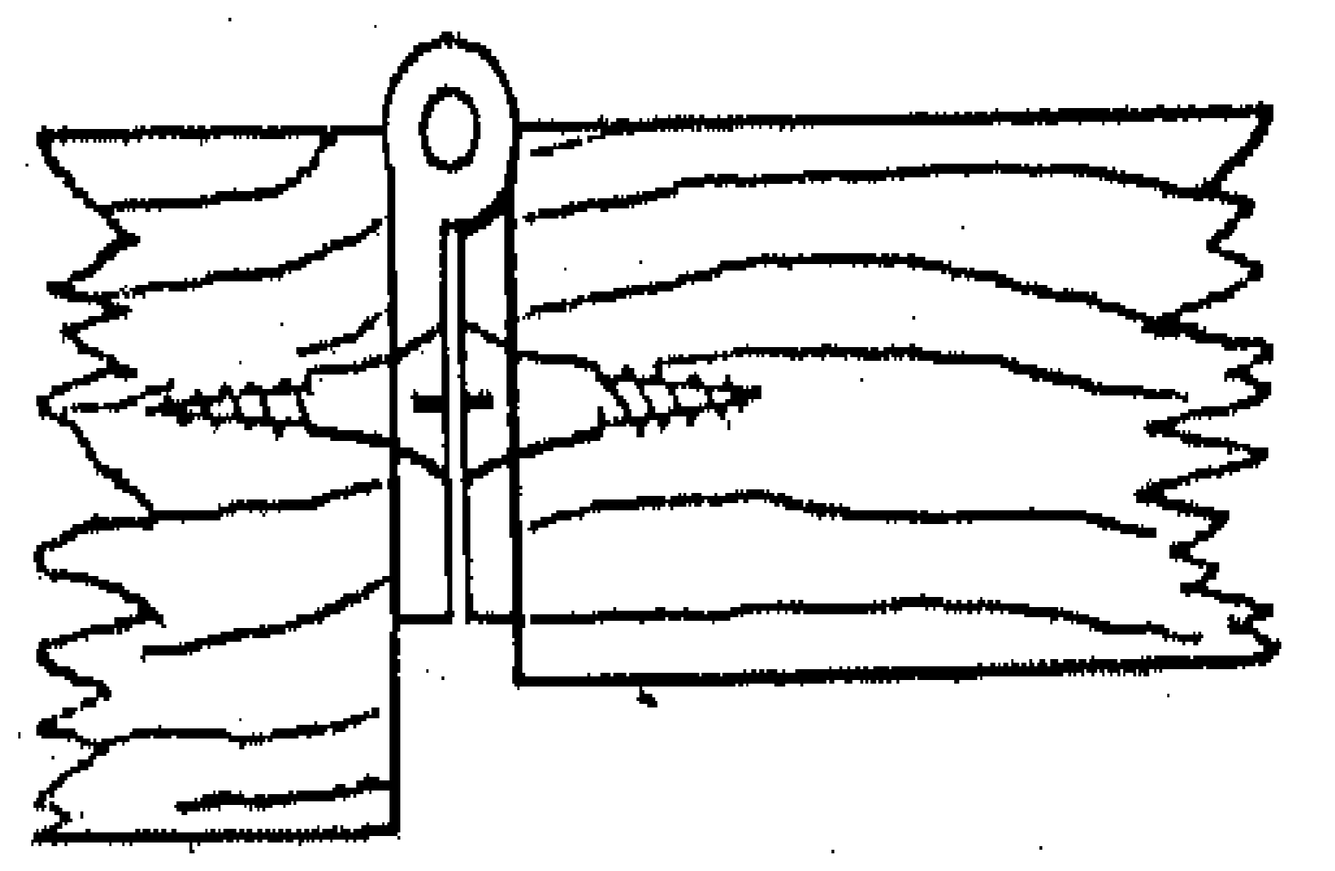


Fig. 2

Butt hinges are used principally for hanging doors where it is necessary to fix the hinges on the edge. There are numerous ways of fixing such hinges, but whichever method is chosen it is necessary to sink the leaves into either one or both of the edges to be joined. This will be clearly understood by referring to Fig. 2, which shows a butt hinge incorrectly screwed to the face of the edge of the door and the supporting frame. Such practice forms a gap as wide as the thickness of the two leaves, which is not only very unsightly but also allows dust to enter should the door be fitted to a cupboard.

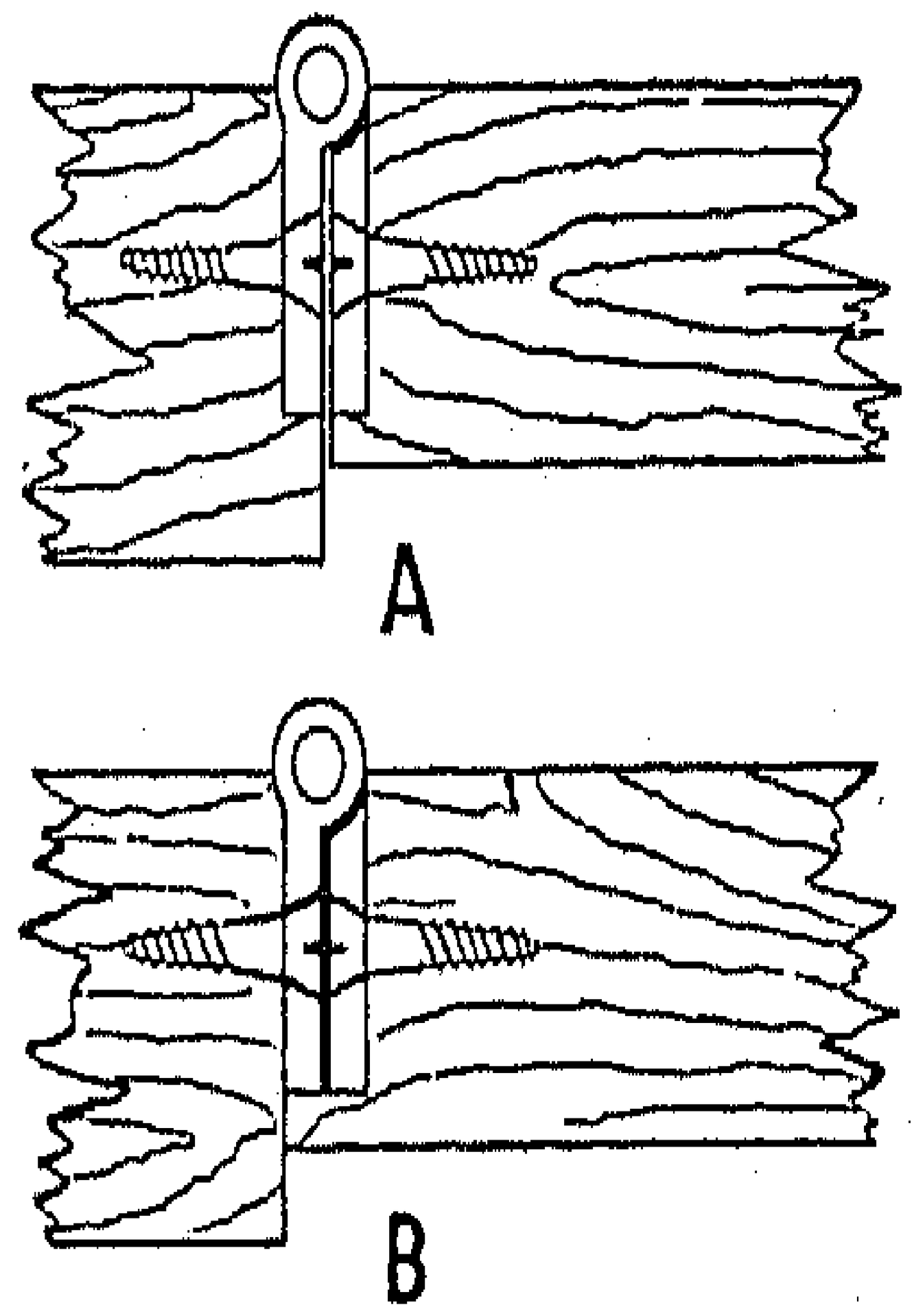


Fig. 3

The usual practice when hingeing a large door is to cut a recess in both the door edge and the jamb, to enable the leaves to lie flush with the respective surfaces in the manner shown at A in Fig. 3.

In the case of hingeing small doors such as those used on cabinets, furniture, etc. it is generally an advantage to cut recesses sufficiently deep to take both leaves in the edge of the door only. This arrangement allows one leaf to be fixed direct to the surface of the frame as illustrated at B in Fig. 3.

As a general rule it is best to allow the centre pin of the hinge to lie in line with the face of the door.

When fitting hinges to a large cupboard proceed as follows:

Place the door, edge to be hinged uppermost, against something to support it. Hold the hinge in the exact position required, keeping the pin in line with the front face of the door, and then scribe a line round the hinge by means of a sharply-pointed pencil. Repeat the process for the other hinge. If preferred, this marking can be done with a marking-gauge by setting the gauge from the hinge itself, and gauging from the long edge of the hinge to the centre of the pin in the manner indicated by CD in Fig. 4. When the lines indicating the width have been marked on the edge of the door, mark off on these lines a distance equal to the length of a hinge. From these marks draw lines at right-angles to the long edge of the door and carry them over to the front face, using a square for the purpose. The next item is to gauge the depth of the recesses which, of course, is equal to the thickness of a leaf as represented at AB in Fig. 4. Set the gauge from the hinge and mark the depth lines on the front edge of the door. The waste is removed by first making a series of saw kerfs and then cutting it away by the use of a chisel.

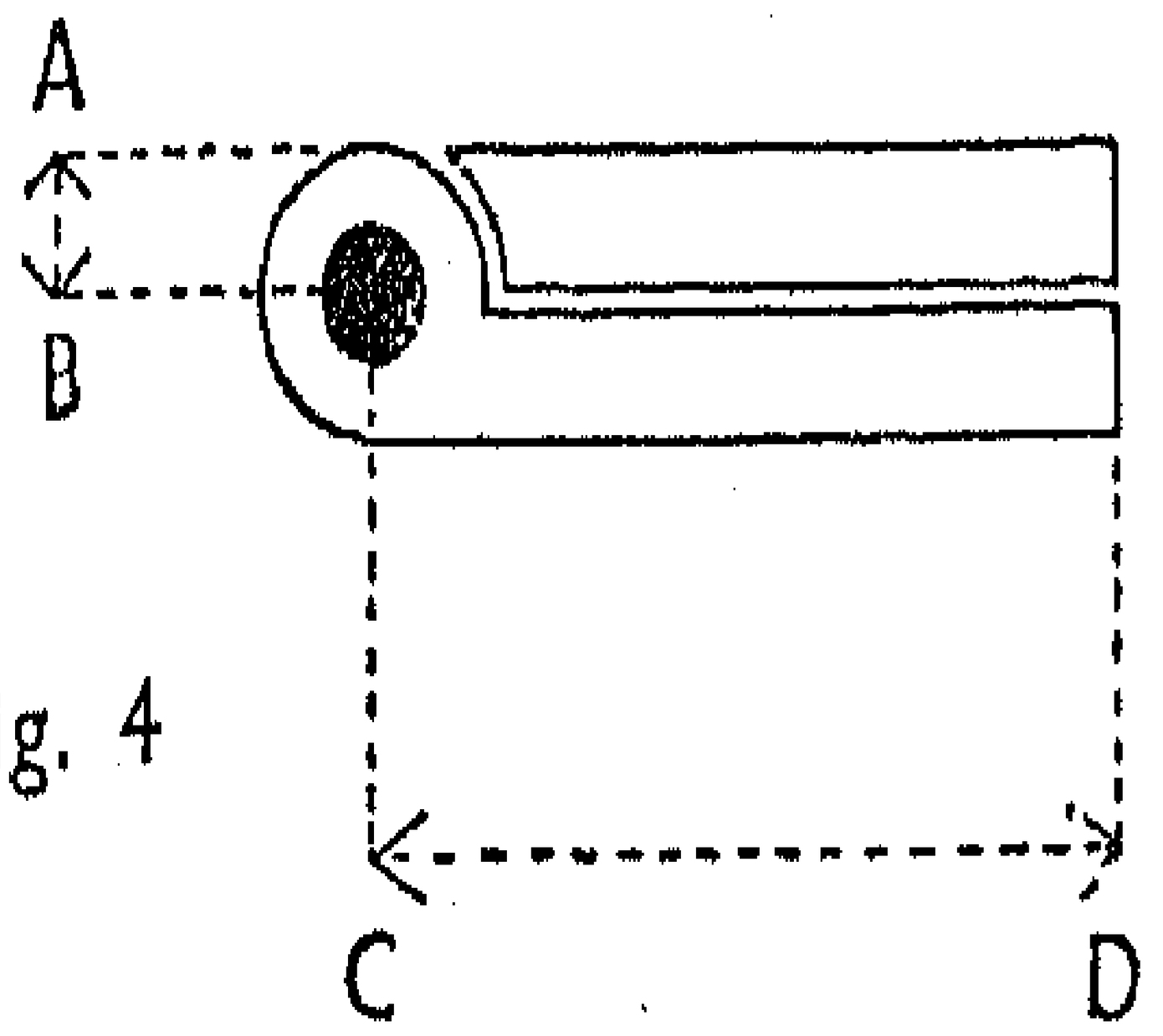


Fig. 4

Fitting the Hinges.—Great care should be exercised to see that they are not set too far in from the front, as this will prevent the door opening to its fullest extent; and if sunk too deeply the door either will not close or, if it does happen to close, it will spring open again because it is hinge-bound. In the latter case, the hinge can be brought up level by packing it underneath with cardboard.

Having fitted the hinges to the door, the next process is to hang the door to its frame. To do this, place the door in its final open position to enable the positions of the other leaves to be marked on the frame. If the door is a large one, a thin wooden wedge should be inserted under the bottom edge to raise it a trifle above the floor level and thus allow the door to swing freely. Care must be taken to see that the door is not raised too high, otherwise the top edge will foul the top of the frame.

The positions for the recesses in the frame are then marked by tracing the outlines of the leaves and marking the depth with a marking-gauge. The waste is then carefully removed with a chisel and mallet. Now place the door in position again (not forgetting to insert the wedge when so doing), and then drive a screw through the middle hole in each leaf into the frame, after having bored the necessary screw-holes with a bradawl.

If the door swings freely, as it should do after removing the wedge, the remaining screw-holes can be bored, the screws inserted and finally driven in.

Locks, like hinges, are to be obtained in many varieties and sizes, and may be classified under three headings: (*a*) those suitable for room doors; (*b*) those employed on cupboard doors; and (*c*) those used for boxes and drawers.

Fig. 5 shows three common forms of locks in everyday use. That illustrated at A represents a simple type of lock, known as a rim lock. Such a lock is useful for unimportant doors where appearance is of little consequence, and the use of a more costly lock is unjustified. A rim lock takes but little fitting as it is fixed on the inside face of the door.

To fit a rim lock, all that is necessary is to sink the projecting flange into the edge of the door, cut the keyhole, and bore a hole for the knob spindle to pass.

The first thing to do in fitting a rim lock is to prepare the recess in the front edge of the door to take the flange. The position for this is usually in line with the centre of the middle rail of the door. Mark this position and from it trace the outline of the flange, using a sharp-pointed pencil for the purpose. Mark a depth line by setting the marking-gauge to the thickness of the flange, and remove the waste with the aid of a chisel and mallet. Next, place the lock in position and mark the positions for the keyhole and spindle hole by pushing the blade of a fine bradawl through the centres of the apertures in the lock, taking care to hold the bradawl perfectly square.

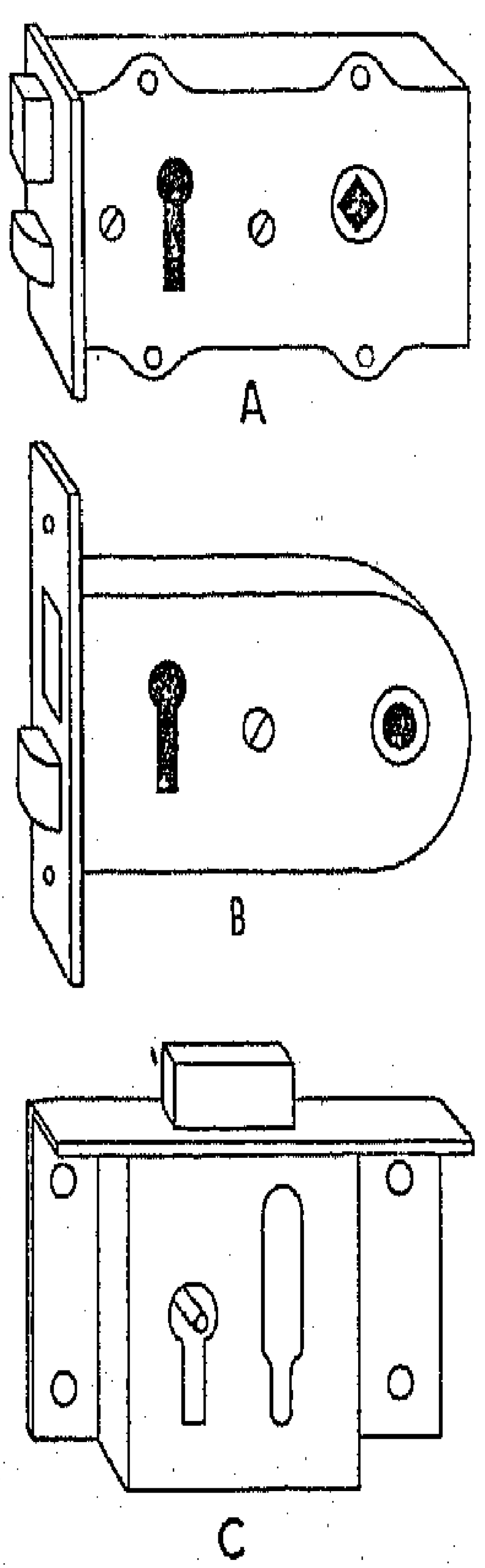


Fig. 5

Select a bit a trifle larger in diameter than the diagonal thickness of the spindle, bore the hole until the point of the tool just appears on the other side, and finish the hole from that side. Great care must be taken to keep the brace perfectly square when boring the hole, otherwise the lock will not work properly. Now prepare the keyhole by first boring a hole a trifle larger than the shank of the key and then making another just below to clear the bottom of the ward. Finish the keyhole by removing waste between the holes, using a pad-saw for the purpose. Now hold the lock in position, insert the key and the spindle from the outside to test whether they work freely. If satisfactory, bore the holes for the fixing screws by means of a bradawl, and drive in the screws.

Fix the small plate or "escutcheon" that surrounds the keyhole and the cover plate for the spindle hole, on the outside of the door. Finally, screw the box staple that receives the latches to the frame, taking care to see that it is centred correctly.

A Mortice Lock (B in Fig. 5) is used for room doors where neatness of appearance is essential. Such a lock is not so easy to fit as the rim lock, as the body or box containing the mechanism is sunk into a mortice cut in the closing stile and centre rail of the door.

To fit a mortice lock, mark the position of the recess on the edge of the door by means of a rule, marking-gauge, and square. Next, select a twist-bit whose diameter is the same as the thickness of the lock, and bore a series of holes as deep as the lock is long, to remove as much waste as possible. Drill the holes as close to each other as convenient, as it is somewhat difficult to clean the end of the mortice. To clear the ends sufficiently, a mortice-lock chisel is used by the expert, but as the amateur does not usually possess such a tool, a similar result can generally be attained by giving a twisting movement to a sharp firmer-chisel.

Having completed the holes, remove the remainder of the waste by using either a morticing- or a firmer-chisel, and clear up the sides with a wide chisel so that the lock fits hand-tight in the recess.

Cutting a Recess.—As some mortice locks are fitted with an additional plate to cover the fixing plate, due allowance must be made for this—if fitted—when gauging the depth of the recess.

Insert the body of the lock into the mortice, trace the outline of the end plate with a sharp-pointed pencil, gauge the depth, and then chisel out the waste.

Now measure and mark the positions for the centres of the handle spindle and the shank of the key, on both sides of the door. Drill the holes through one side only and then slide the lock into the mortice to test the accuracy of the holes. If correct, bore the holes on the other side and finish the keyholes by cutting them down accurately with a pad-saw, taking care not to make the holes too large.

Fix the lock permanently in place by driving screws through the end plate.

Having fixed the escutcheon plates over the keyholes, the spindle plates and handles, the next thing to do is to mark accurately the position for the mortice and the cover plate to take the latches, on the door jamb. Cut the mortice a trifle deeper than the length of the latches and accurately chisel out the recess for the plate. The work is complete when the plate has been fastened securely with countersunk-headed screws.

Little difficulty should be experienced in fitting a drawer lock (C in Fig. 5).

The Keyhole.—Mark the position of the keyhole which obviously comes in the centre of the drawer front. From this point square a line up to the top edge and across it as indicated at A in Fig. 6, then set the marking-gauge from the top plate, to the centre of the pin over which the end of the key fits, and mark the point B. Fix a boring bit, a shade larger than the diameter of the barrel of the key, in the brace, and make the hole at this point. In doing this it is a good plan to hold a piece of waste wood at the back to prevent the bit bursting through, and also to ensure a perfectly clean hole. Drill a smaller hole a little lower down with a bit a trifle larger than the thickness of the ward of the key, and then remove the waste between the two holes with a pad-saw. If, on trying the key, the aperture is found to be too small, enlarge the hole by means of a small flat file.

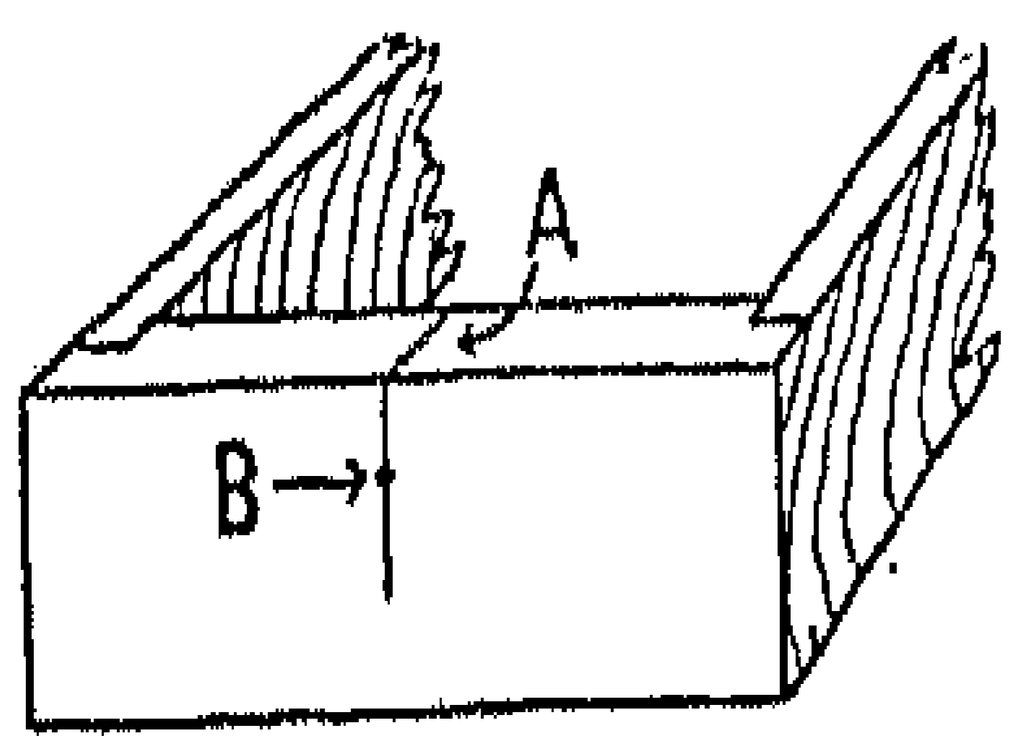


Fig. 6

Now pass the key through the keyhole into the lock, and holding the lock in the exact position for its final resting-place, trace the outline of the back plate. Make sure that the lines so marked are perfectly square by testing with a square.

Carefully chisel out the recesses for the back and top plates and then mark and cut the deeper recess to take the body of the lock. Insert the fixing screws and screw all tightly home.

Shoot the latch out by turning the key, and smear the end with some grate polish, or some other substance that will mark easily. Return the latch into the lock, close the drawer, and turn the key as far as possible in an attempt to lock the drawer. Replace the latch, and on opening the drawer the exact place for the mortice will be clearly visible.

Chisel out the mortice a little deeper than that actually required, countersink the plate, and fasten it with screws. Finally, test to see that all works smoothly, and then fix the escutcheon.

SHARPENING WOODWORKERS' TOOLS

Whatever tools the amateur possesses, whether few or many, the time comes when something or other needs to be done besides oiling the wood or steel to keep them in good condition.

The commonest requirement is sharpening, because wood-cutting tools lose their usefulness as soon as they become blunt.

Of course, the sharpening can be done for you at a fairly low cost by the local tool-dealer, but this generally means delay, as it is seldom that the necessary work can be undertaken at a moment's notice. It is much better to do such jobs for yourself.

Saws are generally considered difficult tools to sharpen, but this is really not so if one goes about the work in a careful and methodical way.

The tools required to sharpen saws include a saw-cramp, a suitable triangular or three-cornered file, a flat file, a saw-set, and the bench vice.

The tradesman generally uses a special type of saw-cramp, but this device is unnecessary for the amateur as one can be improvised by fixing the saw, teeth upwards, between two pieces of board with their outer edges chamfered off, in the bench vice.

The boards must be thicker than the shoulders formed by the handle of the saw, which, in all saws in general use, is just under $\frac{1}{2}$ in. The length of the strips should be a little longer than the saw-blade.

When fitting the saw between the cramps for filing, the teeth should not project more than $\frac{1}{2}$ in. above the level of the top edges. If the saw is allowed to project more than this amount, "chattering" will take place when the file is used. This does not apply when "setting" the teeth, because the height of the saw above the cramps will have to be adjusted to allow the setting tool to be conveniently operated.

It does not necessarily follow that because a saw cuts badly it requires sharpening; it may be that the tool only needs re-setting. If, on examining the teeth, the "points" appear to be a trifle rounded and dull, it usually indicates that the tool requires sharpening. On the other hand, if the points seem to be well defined and clean, it may be taken that re-setting will put the tool into serviceable condition. This should be borne in mind, because a saw generally needs setting more often than sharpening—sometimes as much as three settings to one sharpening.

Assuming that a saw requires a general overhaul, proceed in the following way.

Fix the saw securely between the cramps so that the teeth are parallel to and project $\frac{1}{2}$ in. above the edges.

Stripping.—The first operation consists in filing the tops of the teeth perfectly level from one end of the blade to the other. This is necessary because the teeth usually get more wear in the centre than at the ends, causing the top edge to assume a slightly concave shape. A straight-edge placed on the top of the teeth will enable you to verify this, and indicate where most filing is required.

To strip the teeth, place the file lengthwise over the teeth, that is, the file and saw running in the same direction, and file lightly along the tops, using a smooth, flat file for the purpose.

Take care to keep the file perfectly horizontal so that it does not remove more metal on one side than the other. Press mostly at the ends if the middle happens to be a trifle concave. If you have difficulty in keeping the file straight, it is a good plan to sink the file squarely in a block of wood to act as a guide, as shown in Fig. 1.

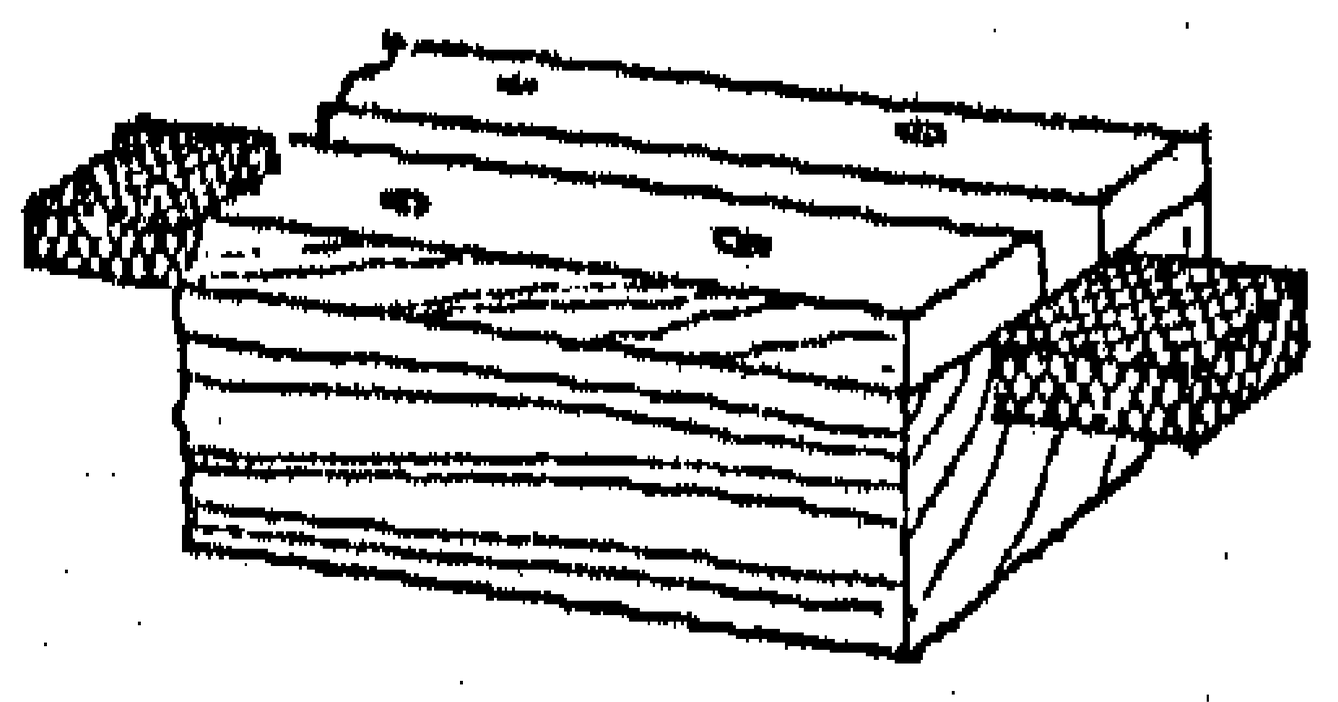


Fig. 1

If the stripping process has been properly done, all the points should appear perfectly level when tested with the straight-edge.

It may be that some of the teeth are a trifle flattened after filing, in which case it will be necessary to file them at the backs.

Setting the Teeth is the next process. This means that each alternate tooth on one side of the blade and each alternate tooth on the other is bent outwards to an amount which depends upon the type of saw. Thus, the teeth of a rip-saw do not require so much set as a cross-cutting saw, and a tenon-saw is set finer than the latter. In any case it is essential that the same amount of set be given to each tooth of a particular saw, so that they are all alike.

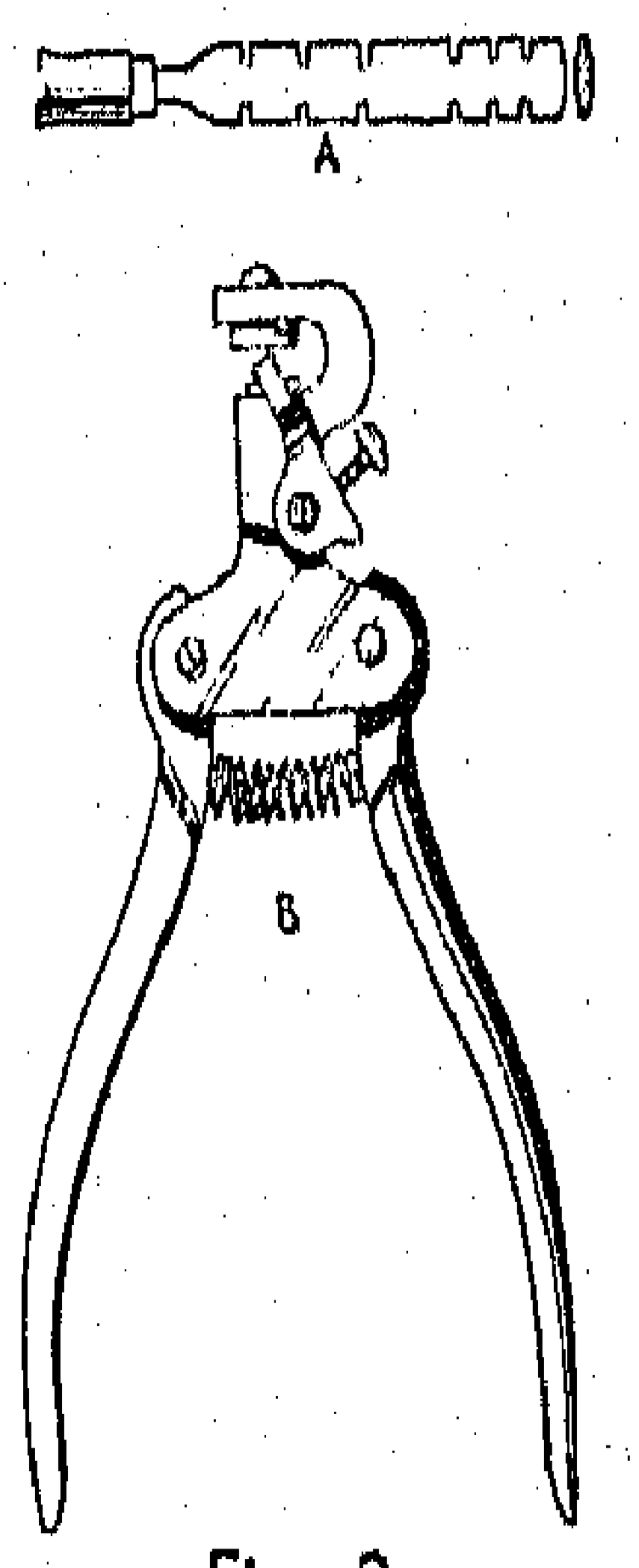


Fig. 2

The Saw-set.—Saw-setting is accomplished with a tool called a saw-set. A common type is represented at A in Fig. 2. It will be seen that the tool consists of a steel blade having a number of slots, and fitted with a suitable handle. The slots are of various sizes to suit different thicknesses of teeth.

The tool is used by fitting a suitable slot over a tooth and pressing it downwards until sufficient set is produced. This type of tool certainly has the advantage of being cheap to buy, but it is not recommended for use by the inexperienced worker as a considerable amount of skill is needed to judge the amount of bending, and it is an easy matter to break the teeth if the work is not carried out properly.

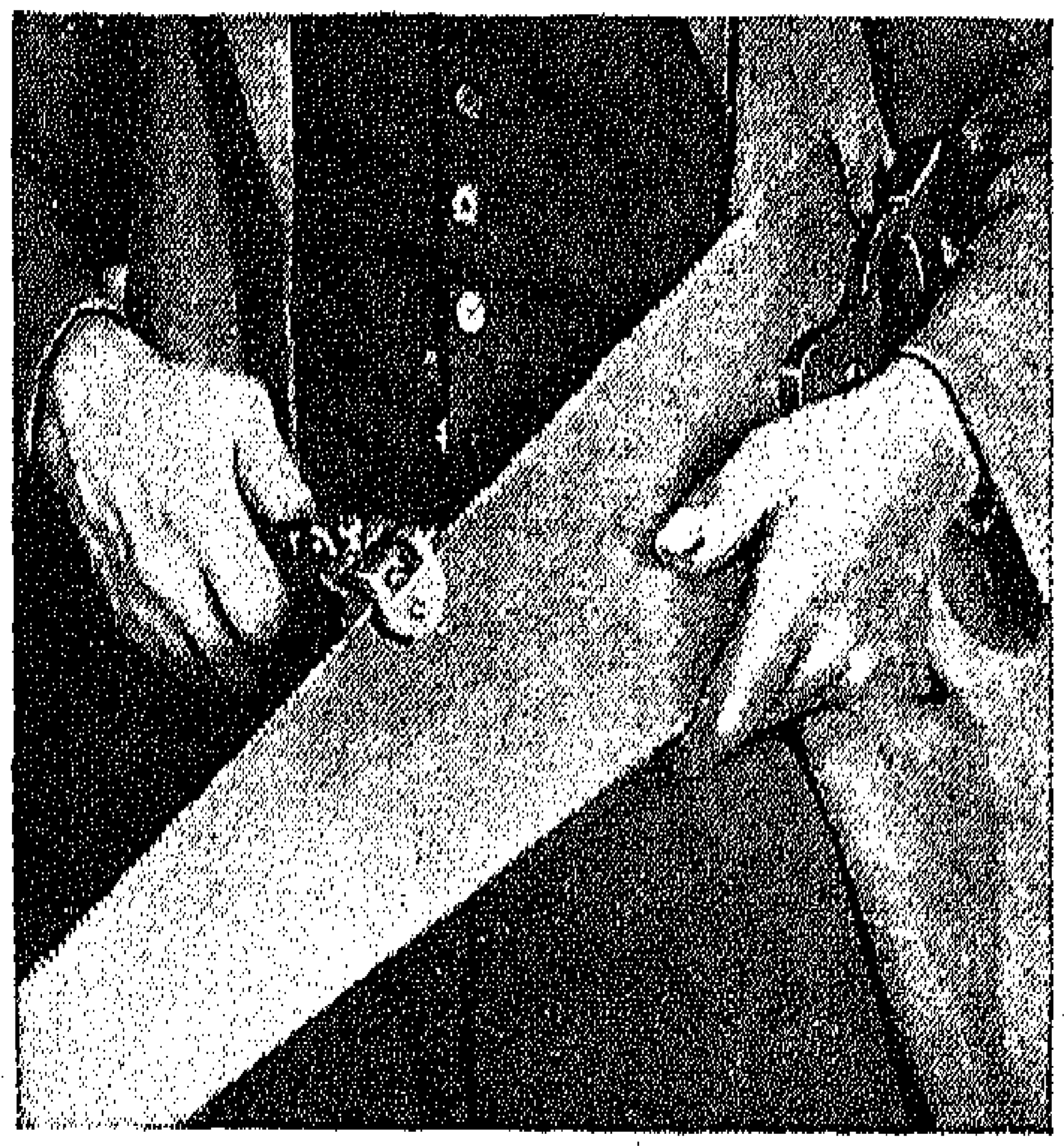


Fig. 3

The Mechanical Saw-set (Fig. 2, B) is an excellent tool for the handyman, because the amount of set can be regulated by a screw and this enables the teeth to be bent exactly alike. To use the tool the screw is first adjusted to give the desired degree of set, the jaws are fitted over a tooth, and the handles pressed together in the same way as a pair of pliers.

It should be noted that only the points of the teeth are bent over, and that the operation should not be attempted on a very cold saw. It is safer to warm the saw and the saw-set prior to operations, and to carry out the work in a warm room. During the winter the best place is obviously in front of a fire, not only for the worker but also for the saw. Fig. 3 shows the operation.

Filing the Teeth.—A tapered triangular file about 4 or 5 in. long will be required for treating hand-saws, while a smaller tool will generally answer the purpose for tenon-saws.

Fix the saw between the cramps as already mentioned, taking care to see that the teeth do not project more than $\frac{1}{2}$ in. above the edges of the cramps.

Grasp the handle of the file in the right hand, keeping the thumb on top, and hold the point of the tool with the left, in the manner indicated in Fig. 4. File those teeth that have had their points removed during the stripping process first. When this has been done, file down into each alternate V-groove so that the back of each tooth and the face of the next is treated, then reverse the blade in the cramps and proceed with the other side.

In using the file give the same number of strokes—one or two only—to every tooth, and make the strokes of equal length and pressure.

If a Rip-saw is being Sharpened use the file horizontally and keep it square with the blade. In the case of a cross-cutting saw hold the file obliquely to the saw-blade and keep the point of the tool inclined upwards to an angle of about 15° or more to the horizontal. This can easily be done by following the angle of the original cut.

A good test for determining the accuracy of a cross-cutting saw after it has been set and sharpened can be carried out by holding the saw, teeth uppermost, and placing a needle lengthways in the groove formed by the bent points of the teeth. If the needle slides without interruption from one end to the other on tilting the saw, it is a sure indication that the work has been carried out satisfactorily.

Sharpening Plane-irons, chisels, gouges and similar tools is a much simpler process than sharpening saws, and usually only requires the use of an oilstone and the occasional use of a grindstone.

Two stones are recommended for sharpening these tools, one being a coarse carborundum and the other a good quality Arkansas or a Washita. The latter should be neither too hard nor too soft, but of a medium hardness. A serviceable size for these is 6 in. by 2 in. by $\frac{5}{8}$ in. They should be sunk into a block of wood and provided with a cover to keep out dirt and grit.

If you neither possess a grindstone nor have easy access to one, the coarse carborundum stone previously mentioned will generally be found a good substitute.

Each time you sharpen the cutting-edge of a chisel, etc., rub down the bevel also. The bevel should be a little longer than the width of the cutting-edge in the case of a firmer-chisel, but in a paring-chisel it could be almost half as long again, bearing in mind that the sharper the angle the weaker the edge and therefore it will be more likely to notch and break, although a sharp angle means cleaner cutting.

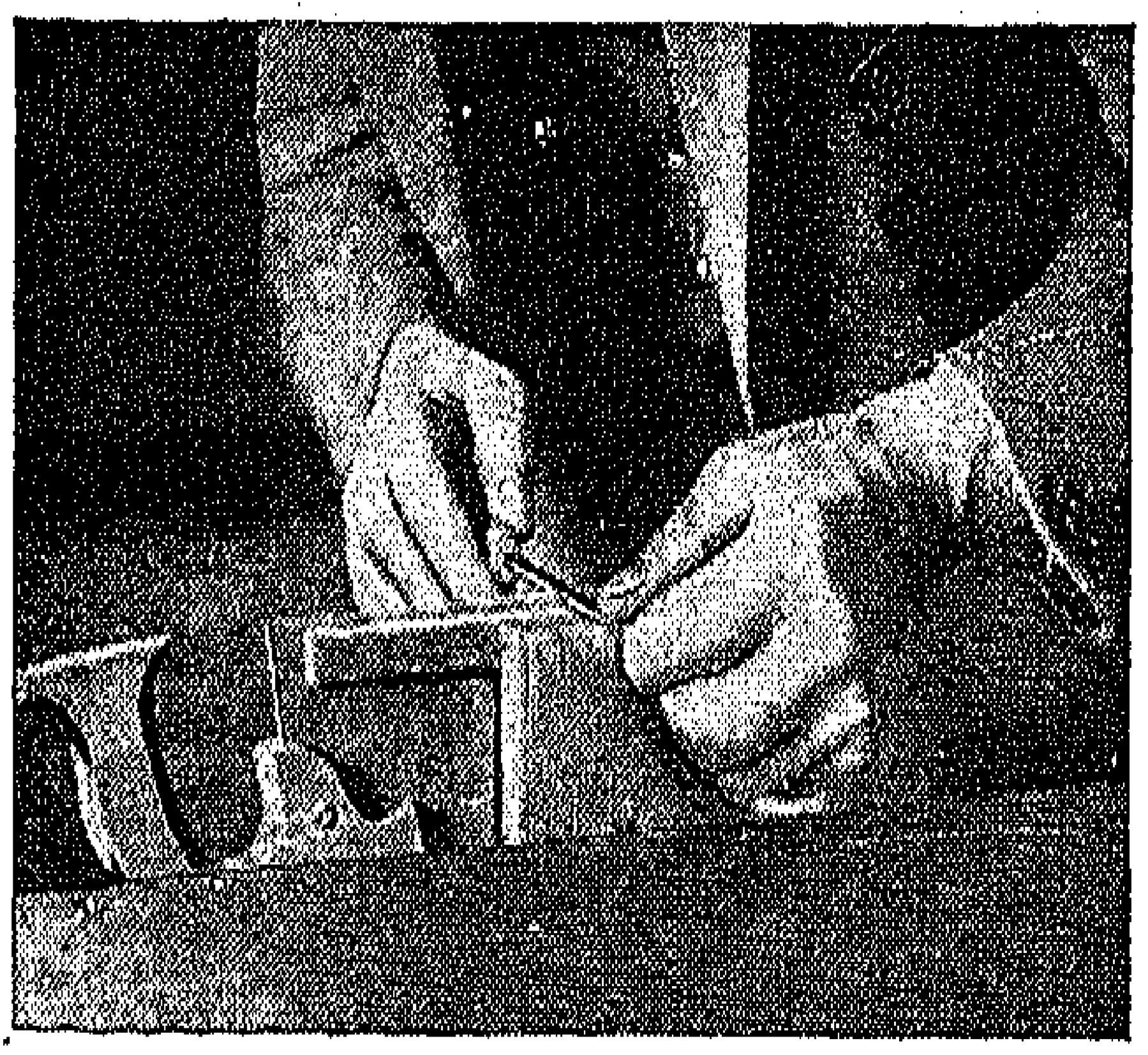


Fig. 4

Assuming that you wish to sharpen a chisel, and that you have a coarse stone and an oilstone as suggested, proceed in the following way.

Treat the bevel first by means of the carborundum stone.

Apply a few drops of thin oil to the surface, taking care that the oil is really thin. A thick lubricant tends to make the tool glide over the surface rather than "bite" on the stone and sharpen it.

Hold the chisel, bevel side down, with the right hand, and press the fingers of the left on the blade just above the cutting-edge, keeping the bevelled face flat on the stone. Now move the tool forward over the surface of the stone, applying a little pressure with the fingers. Relieve the pressure at the end of the stroke and draw the blade back to its original position, and repeat these movements until the bevel is perfectly flat.

Test the Squareness of the Edge by means of a square and if one corner is a trifle "high" more pressure must be exerted on that point when rubbed over the stone again. You will now have a clean straight bevel, as shown at A in Fig. 5, with probably a definite "wire" edge or burr projecting from the flat side of the cutting-edge of the tool. If such is the case place the plain face of the chisel flat on the stone and give it one or two light rubs, taking care to keep the tool perfectly flat.

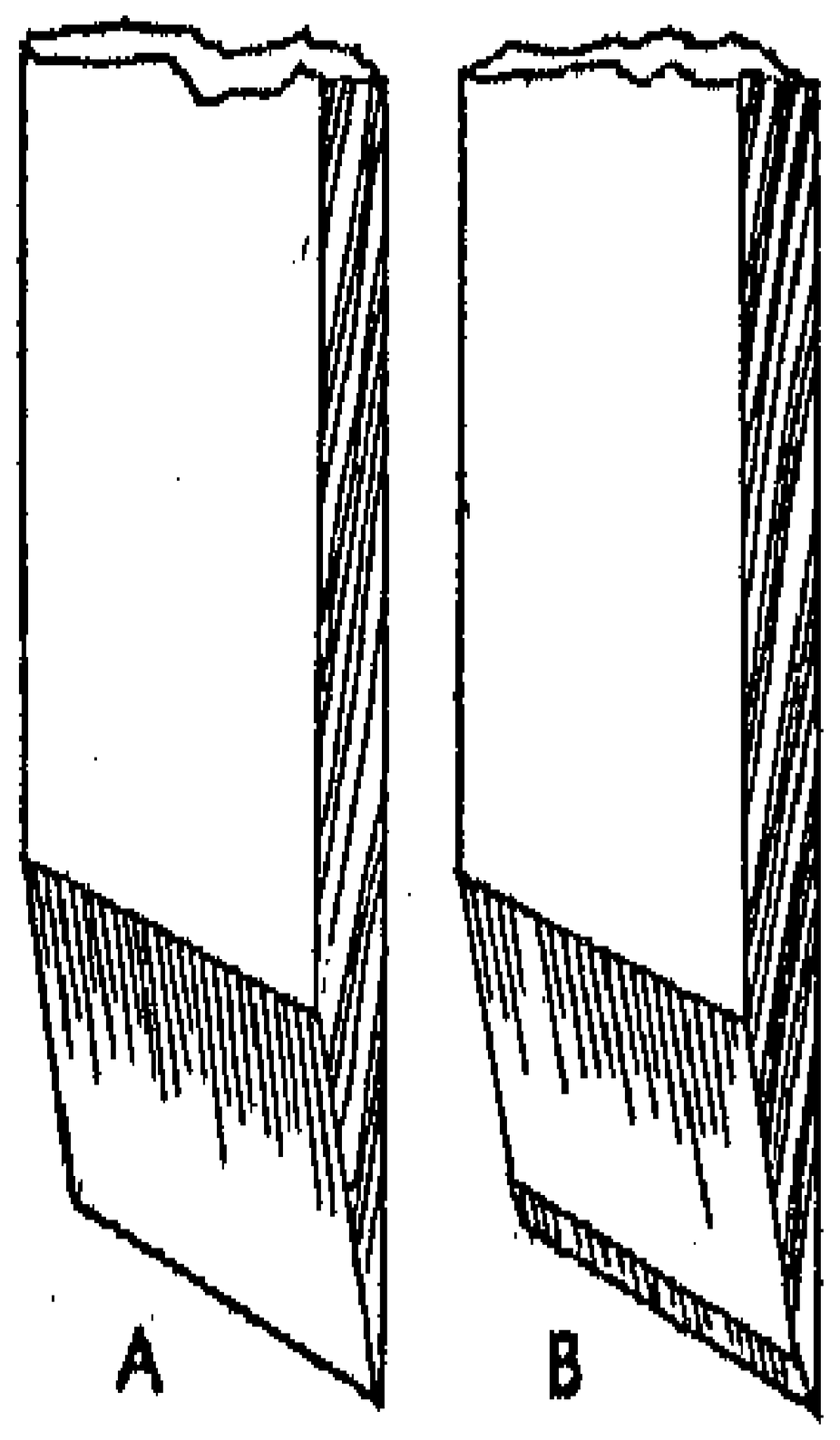


Fig. 5

The medium oilstone will now be required to finish off the cutting-edge. Apply a few drops of very thin oil, such as kerosene.

Hold the chisel in the right hand and lay the fingers of the left on the blade, keeping the thumb under the handle end of the blade, as indicated in Fig. 6. The tool is held at a slightly wider angle than when treating the bevel to obtain a slightly more obtuse angle at the cutting-edge, as shown at B in Fig. 5. The tool is then moved back and forth over the stone in the manner already described.

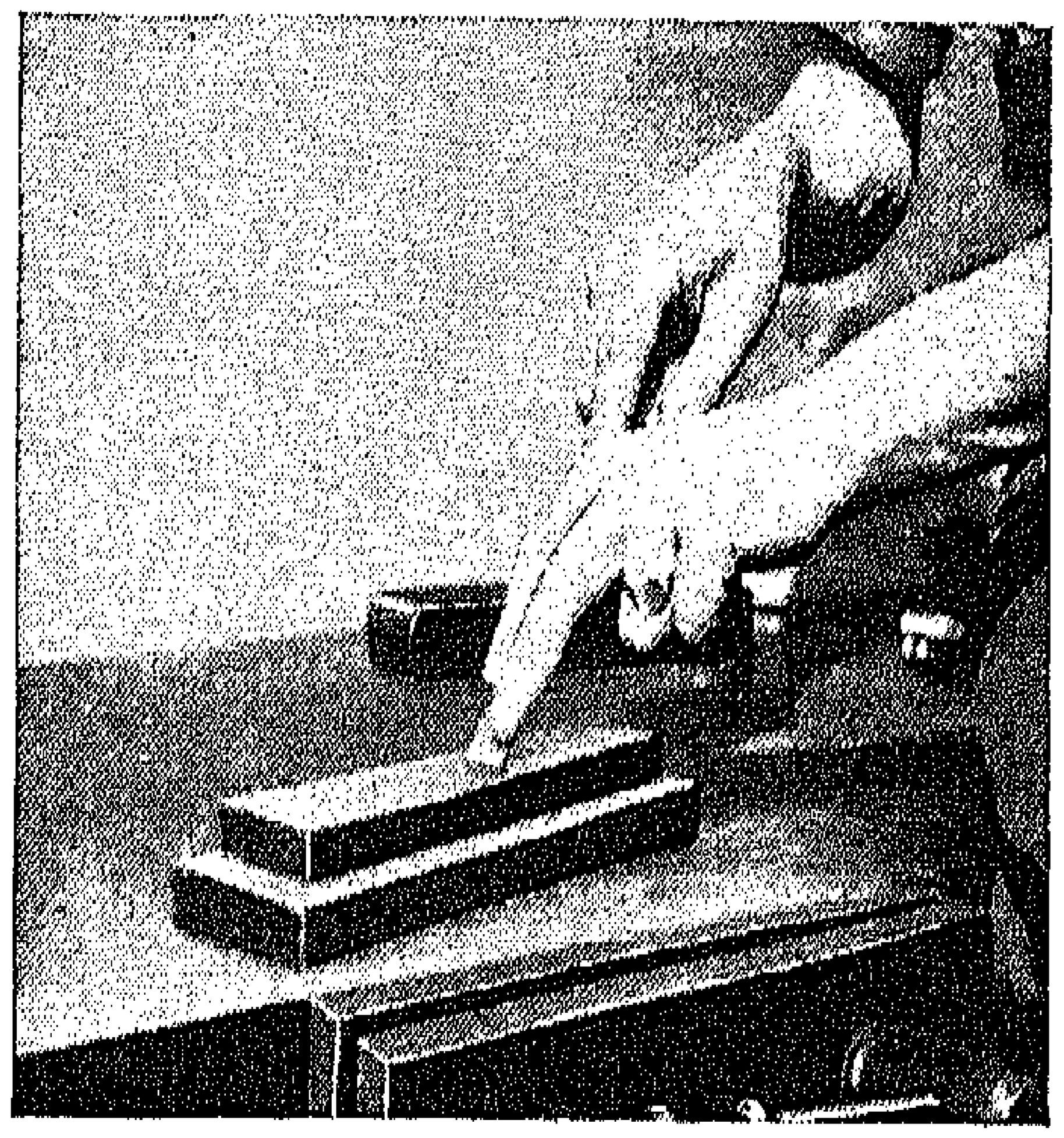


Fig. 6

This operation is continued until a burr appears on the flat side of the tool, which is a good indication that the edge is sufficiently sharp. When this occurs, turn the chisel over and give the back one or two rubs to remove the burr, as already explained. Great care must be exercised whilst doing this to keep the blade perfectly flat on the stone, as any indication of a bevel on the flat side of the tool will ruin its cutting capabilities.

In sharpening chisels some workers prefer to "run" the cutting-edge parallel to the long edge of the stone, while others hold the tool at an angle to the edge of the stone, and some rub the tool along the surface, using a circular or curved stroke. The best plan is to try each method and then use the one you can manage best.

Plane-irons require frequent sharpening to keep them in serviceable condition, as a blunt tool, or the slightest notch in the cutting-edge, will mar the surface of the work.

Plane-irons, like chisels, are sharpened on an oilstone, and treated similarly.

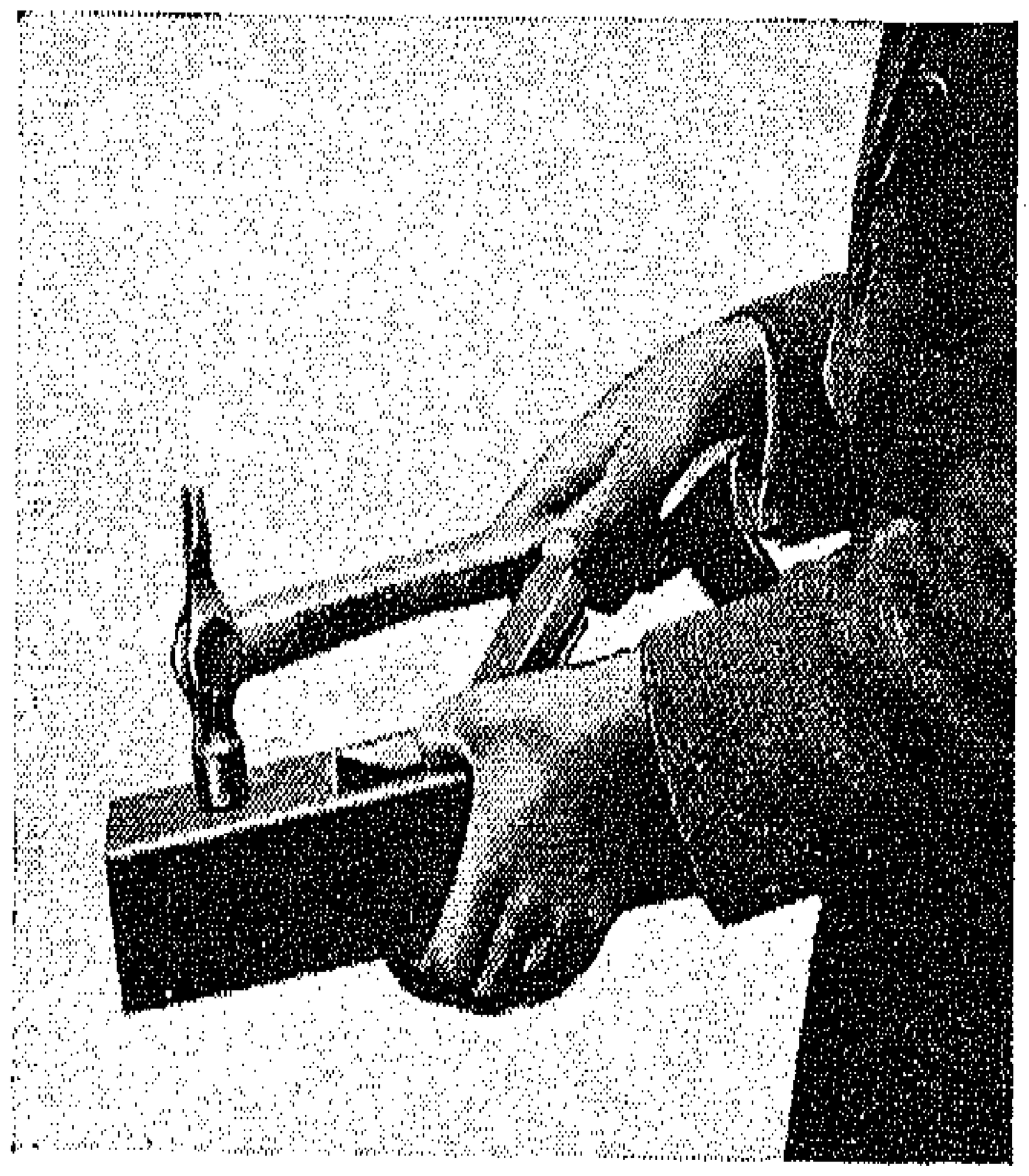


Fig. 7

After having removed the iron from the body of the plane by holding the stock with the left hand and striking the front, as in Fig. 7, the back iron must be separated from its fellow member, the cutter. To do this it is advisable to place the component flat on the bench and then unfasten the screw, as it is dangerous to attempt to turn the screw while it is held in the hand.

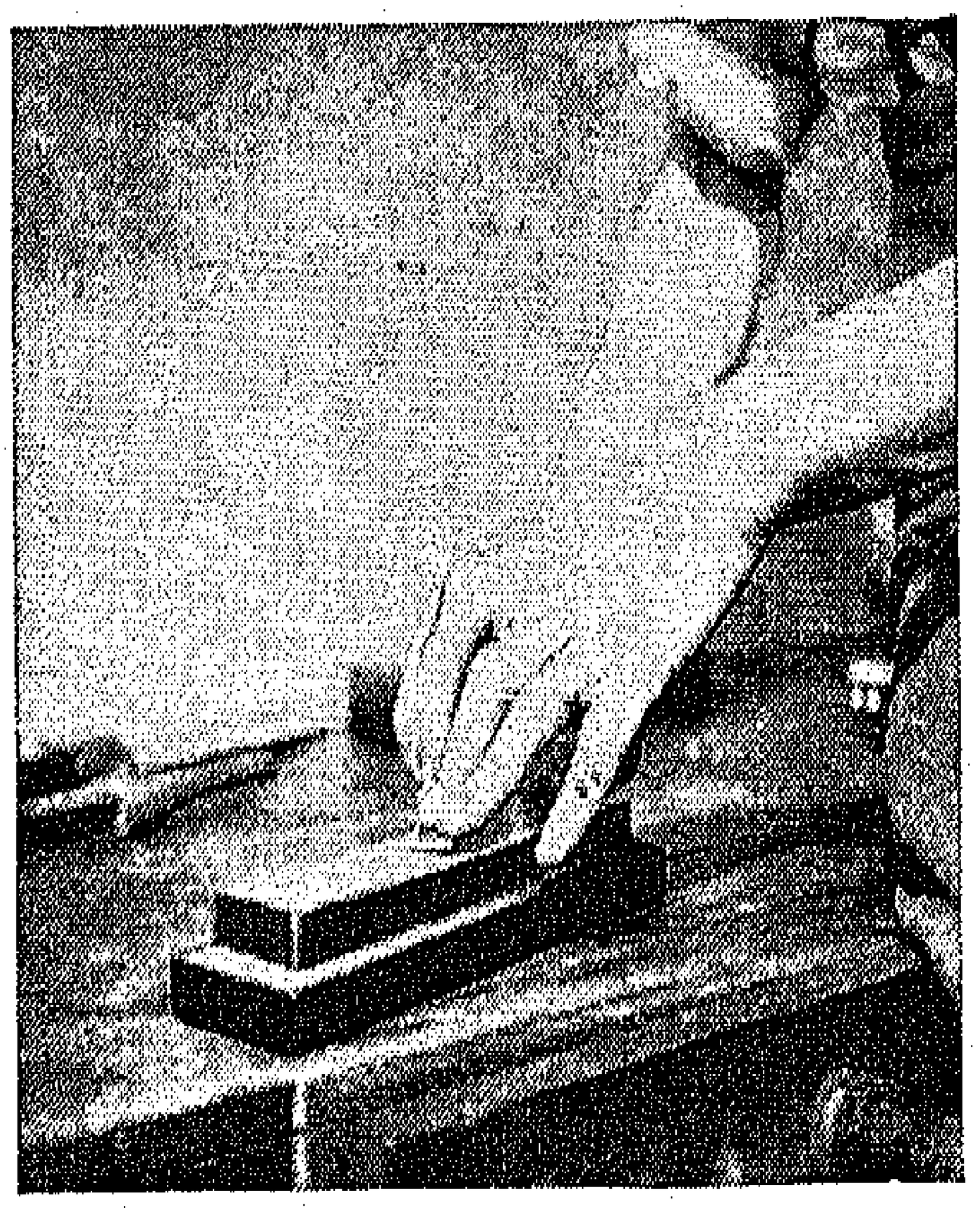


Fig. 8

Put a few drops of oil on the oilstone, and place the bevelled edge flat on the surface, and then raise it a trifle to obtain the correct cutting angle as in sharpening a chisel. Move the cutter back and forth over the surface with a more or less circular sweep. If the stone is not wide enough to take the whole of the cutting-edge when held at right angles to the edge of the stone, the iron should be held obliquely to ensure that the whole of the cutting-edge remains on the surface. This is an important point. Failure to do so invariably results in an unequal sharpened edge, and may also put it out of square. When a burr forms, showing that the edge is sharp, reverse the iron so that it lies perfectly flat on the stone and give it one or two rubs to remove the wire edge. Fig. 8 shows how the cutting-iron is held whilst being sharpened on an oilstone.

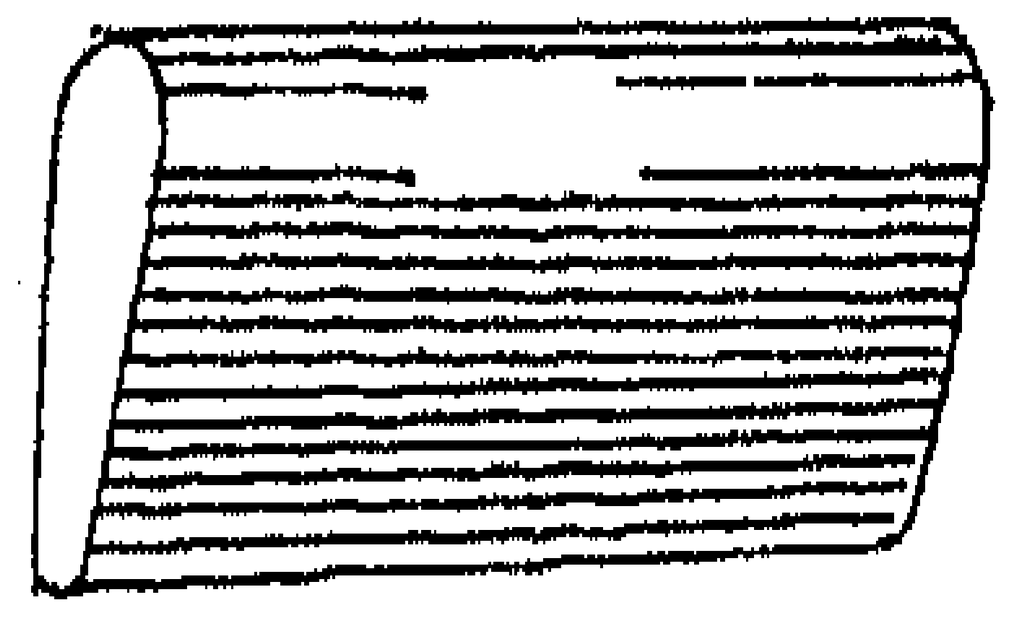


Fig. 9

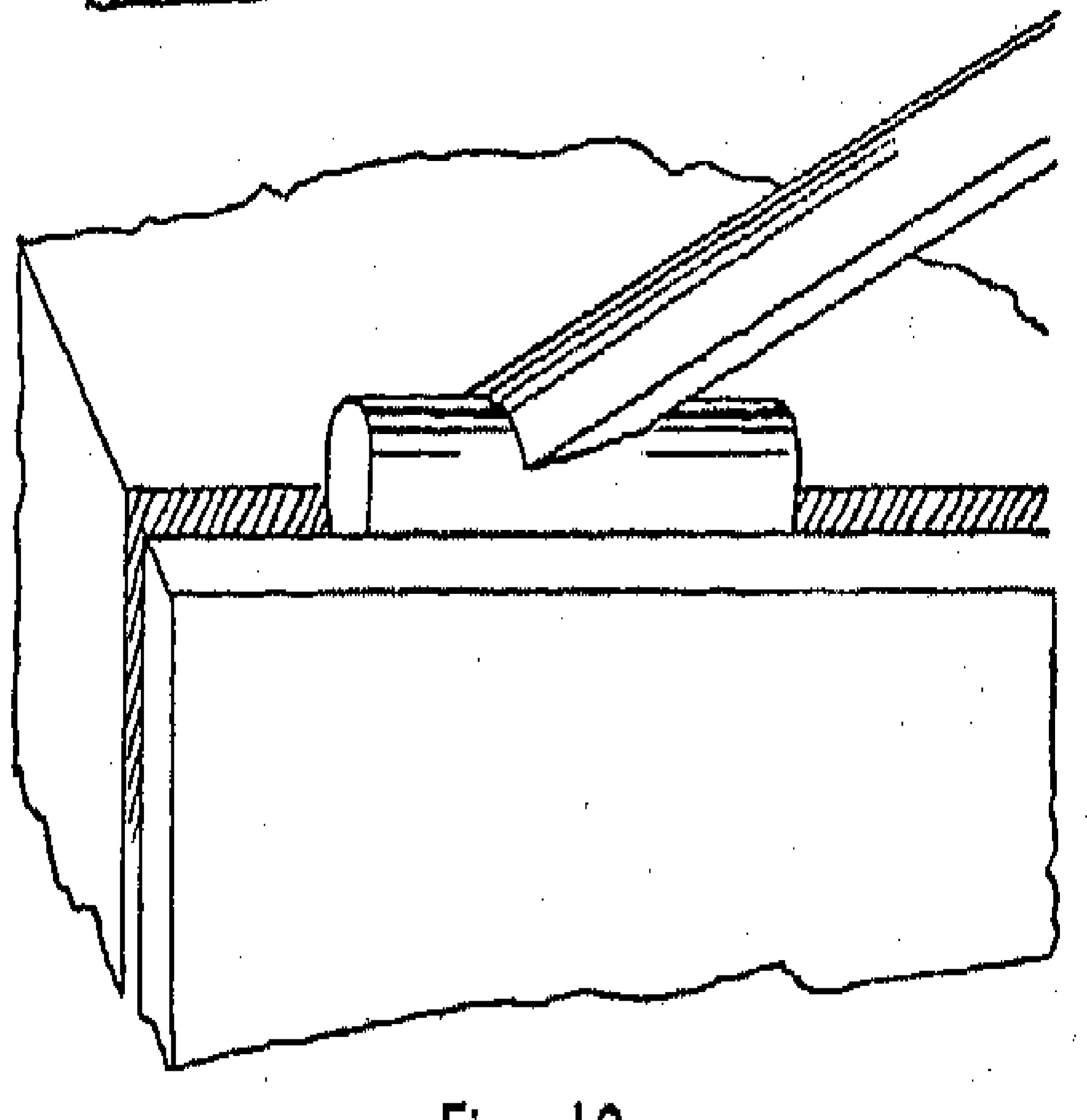


Fig. 10

The Slip, a wedge-shaped oilstone with rounded edges, is required for sharpening internally-ground gouges. Such an oilstone is illustrated in Fig. 9.

In sharpening an internally-ground gouge, that is, one having the bevel on the concave face of the blade, the stone may either be held in the vice, as indicated in Fig. 10, or in the hand in the manner shown in Fig. 11. The former method is perhaps better as the tool can be sharpened in practically the same way as a chisel by rubbing it up and down the curved face of the slip. The burr left on the outside edge is then removed on an ordinary oilstone, by placing the blade flat on the surface and giving it one or two rubs along the stone. The tool should be given a turning movement during the process to ensure that the whole of the edge comes in contact with the stone.

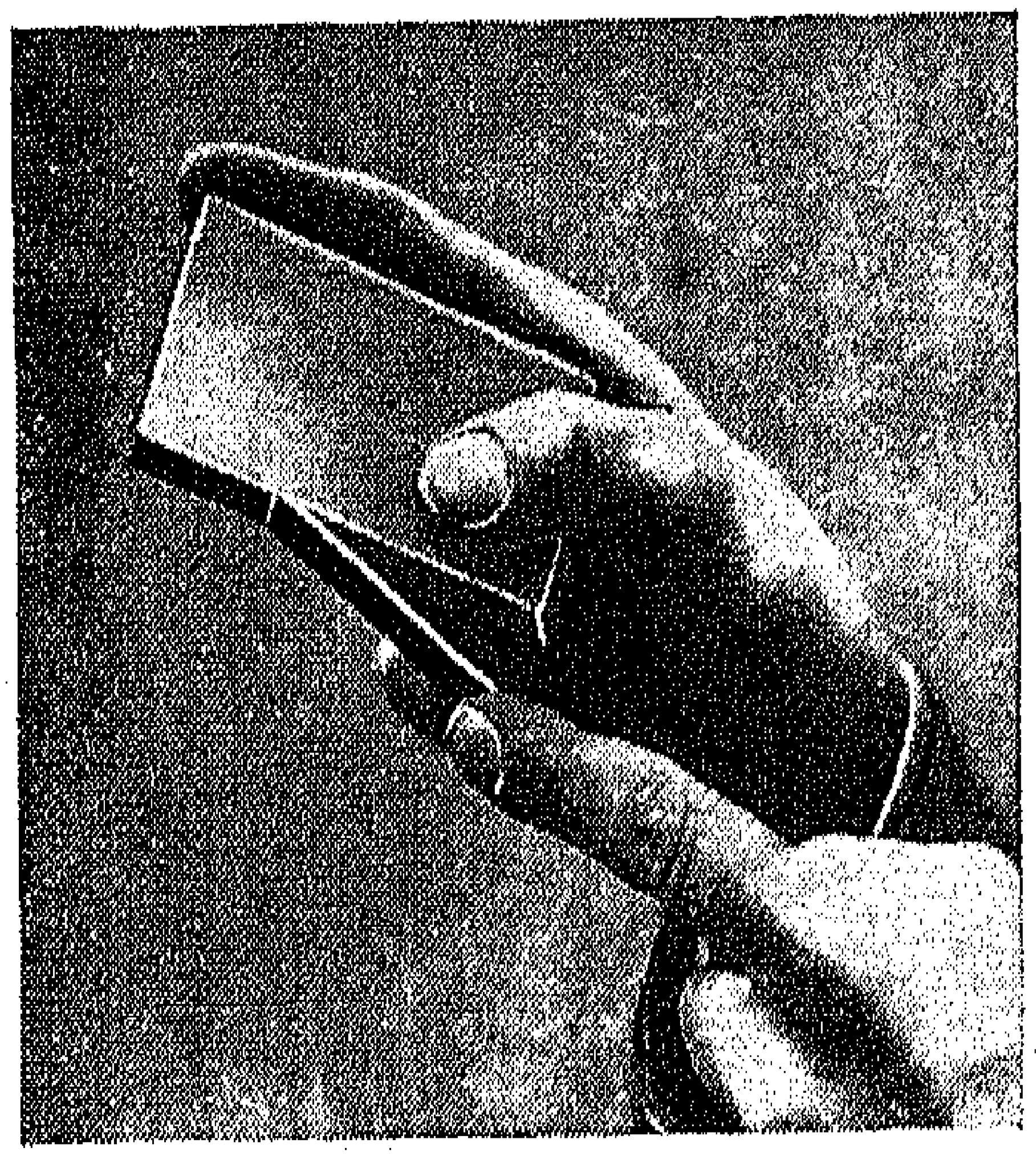


Fig. 11

When using the hand method of holding the slip, the tool is held in the left hand and the slip in the right. The slip is then rubbed up and down against the cutting-edge, care being taken to see that the whole of the edge gets the same amount of treatment.

The oilstone slip is, of course, lubricated with one or two drops of thin oil as in the case of the flat stone.

An Externally-ground Gouge is sharpened by rubbing its cutting-edge back and forth on the oilstone, as shown in Fig. 12. The tool is held at an angle to the long edge of the stone and at a slightly larger angle than that of the bevel to obtain a fine cutting-edge.

The blade is given a circular turning movement as the work proceeds, to ensure equal thickness of the whole length of the cutting-edge. The burr formed on the inner edge is then removed with an oilstone slip.

Clean holes can only be produced by using sharp bits, because dull cutting-edges simply break the fibres of the wood instead of severing them.

When any fibres are left on the walls of a hole after being bored it is usually a sign that the tool needs attention.

Sharpening a Centre-bit.—The centre-bit consists of three principal parts, namely, the "centre" or guide-point, whose object is to guide the bit in its passage through the wood; the "nicker" or outside pointed cutter, which severs the fibres at the outside diameter of the hole to be cut, and the "knife-cutter," whose purpose is to cut out and remove the waste.

If a bad hole is produced when using a centre-bit it usually indicates that either the nicker or the cutter, or both, require "touching up," as it is seldom that the point needs attention.

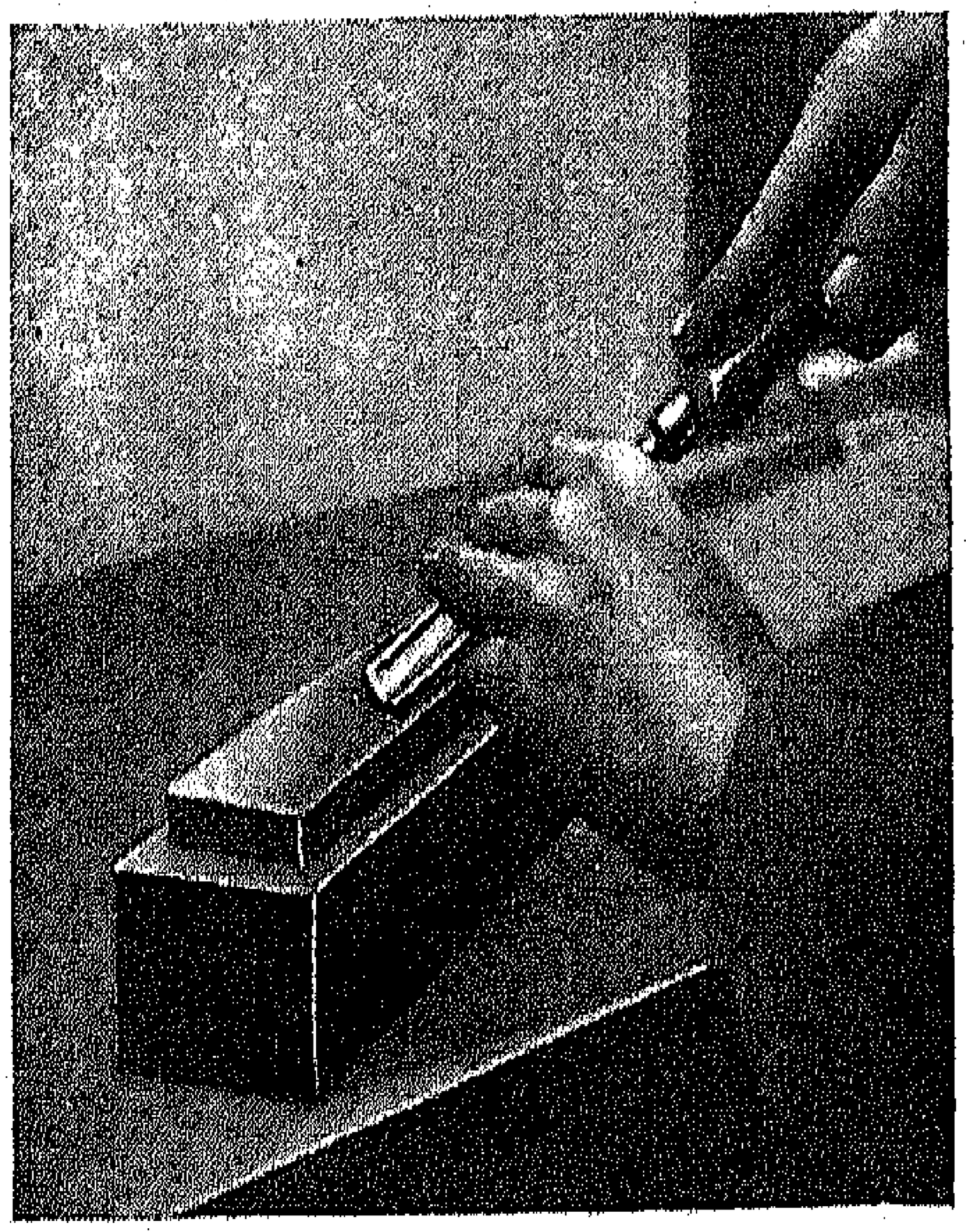


Fig. 12

Should the guide-point happen to be blunt or the corners rounded, the fault may be rectified by filing the prong by means of a smooth file. This can be done either by fixing the tool upwards in the vice or by holding it in the left hand and placing it on a piece of wood on the bench, and filing each face until sufficient metal has been removed to form a new point. Care must be taken, however, when doing this not to take off too much metal, otherwise the point will be level with or below the level of the nicker and thus render the tool useless.

Any filing of the long edge of the nicker must be done from the inside, that is, between the nicker and the centre-point, because any metal removed from the outside will reduce its cutting diameter.

If the top of the nicker requires attention, take care to see that the edge slopes back to give the correct clearance angle, otherwise the edge will merely scratch the wood instead of cutting it. It is also equally important to ensure that the cutting-edge of the nicker does not come below the level of the interior sloping cutter.

The inclined cutter for removing the waste wood is treated with a smooth, flat file, working it towards the cutting-edge in the manner shown in Fig. 13. The chief point to observe when dealing with this part of the tool is to maintain the original inclined angle.

Any burr thrown up after filing the various parts can be removed by the oilstone slip or the ordinary flat oilstone.

The cutting-edges of twist-bits are so varied that one can only recommend the worker to note carefully how the cutting-edge is formed, and then treat them accordingly. In some cases a rat-tail file, in others a flat file, is necessary.

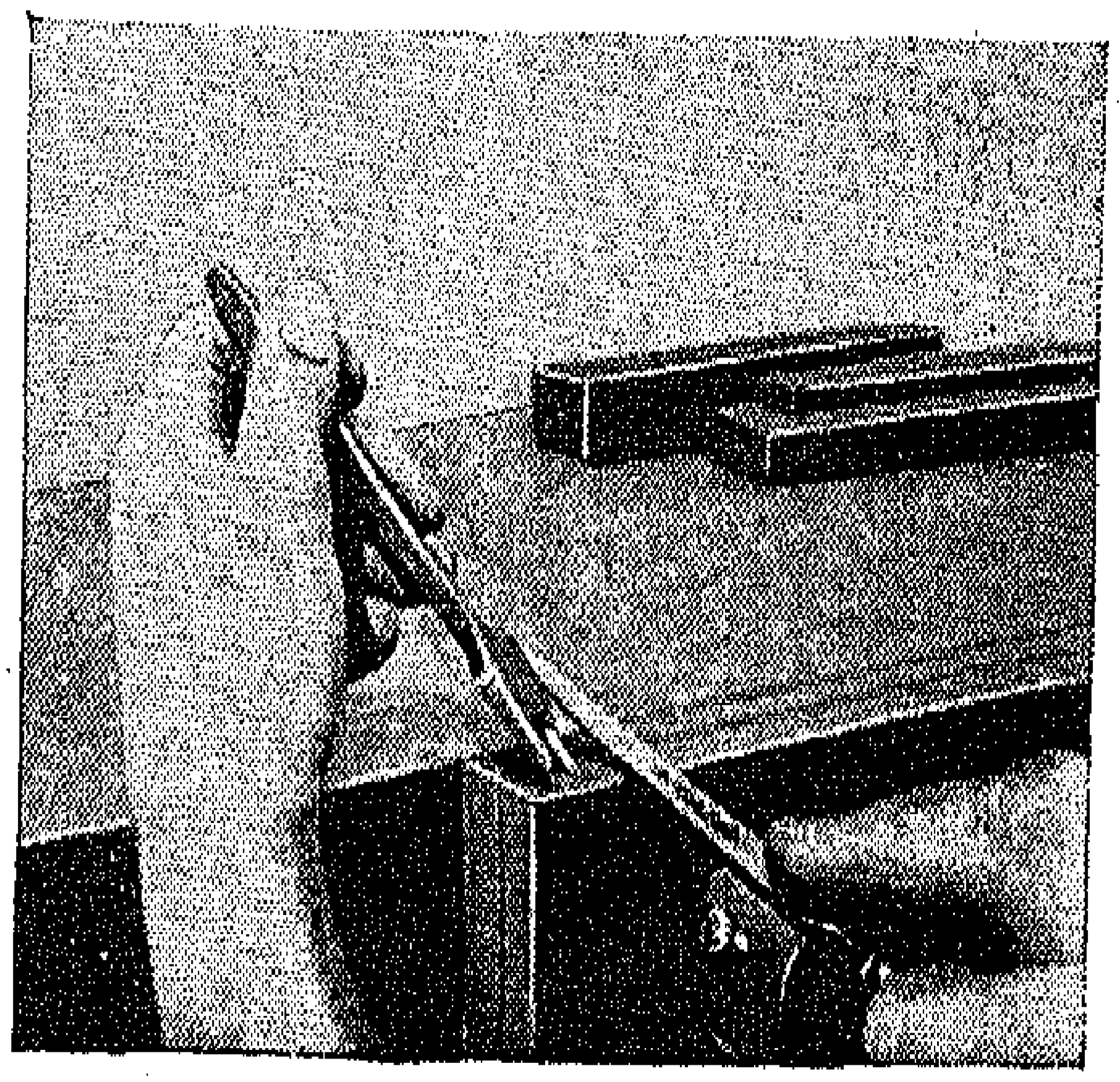


Fig. 13

It may appear curious to refer to sharpening a screw-driver, but this operation is often needed, especially when the working end of the blade has been burred over by careless usage.

A good method of reconditioning such a tool is to place it, blade uppermost, in the vice, and file the edge to a narrow level face. The edge can then be thinned down to the required thickness by rubbing the bevelled faces on a coarse carborundum stone.

Hand-driven Emery Grinding Machines can now be obtained at a cost of a few shillings. They are particularly useful for grinding both woodworking and metal-working tools as the interchangeable abrasive wheels may be obtained in various forms and degrees of hardness.

GLUE AND GLUING

GOOD glue is one of the greatest aids to the woodworker, but if it is of poor quality it is worse than useless. A good quality glue can be distinguished by its clear amber colour, while its texture is hard, somewhat brittle, and it is practically odourless.

There are several kinds of glue, including English, French and Scotch. Scotch glue is the strongest. Then there are several varieties of proprietary glues, sold ready for use, all of which are excellent adhesives and generally used cold.

Before ordinary glue can be used it must be prepared and melted and, as it is applied hot, a suitable glue pot must be provided.

The Glue Pot.—Fig. 1 shows the type commonly used. It consists of an inner and outer vessel: the inner one to hold the glue, and the outer to contain the water. In these days such a pot can be obtained very cheaply at almost any ironmonger's shop. A good substitute for a glue pot is a treacle tin placed in a saucepan, but as the bottom of the inner container must not touch the bottom of the outer one, something should be placed between the vessels to satisfy this requirement.

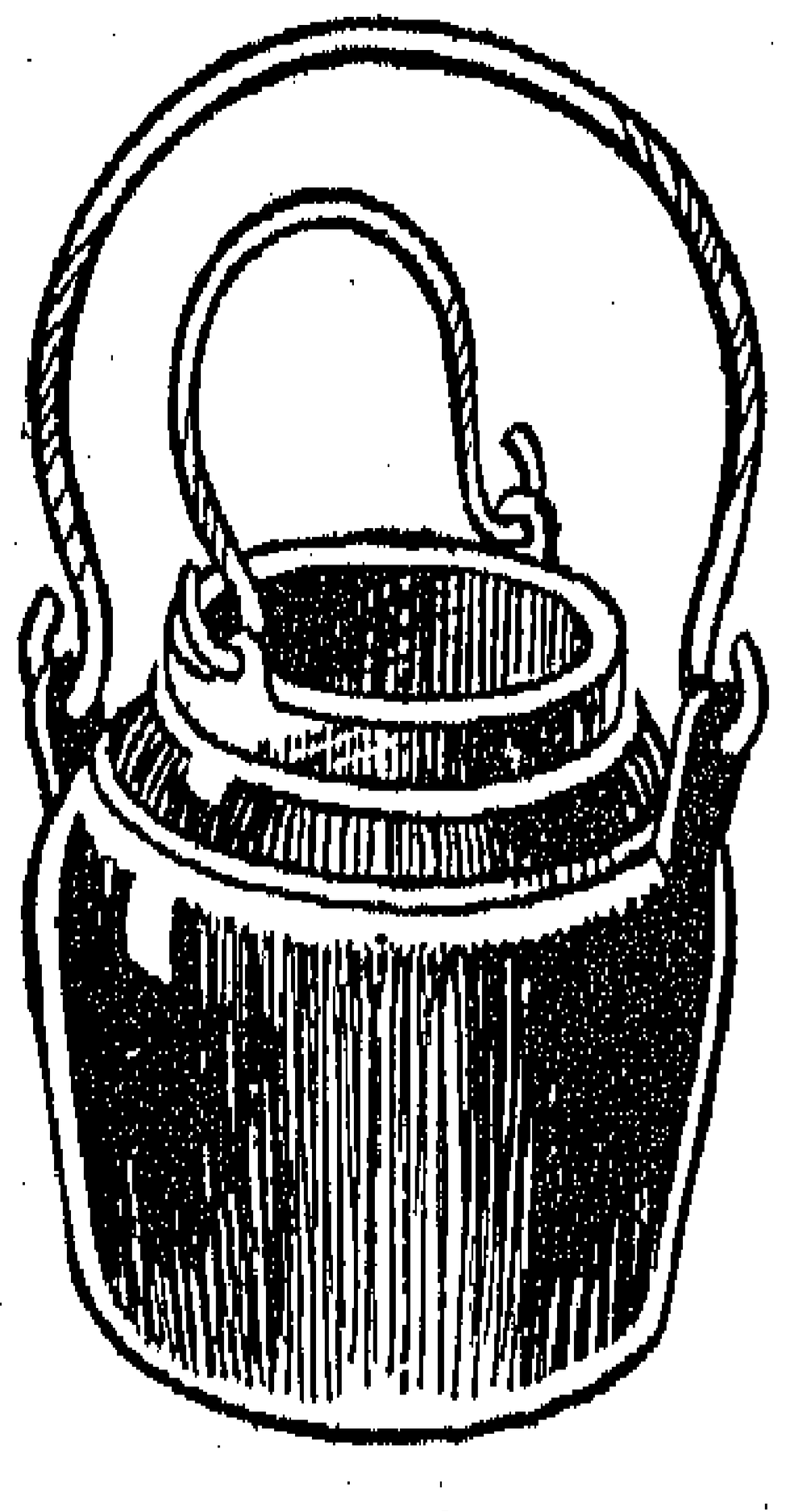


Fig. 1

Preparation.—Break a piece off the cake—it is usually sold in cakes of about 6 in. square, at so much per pound—sufficient for your requirements, remembering that glue swells considerably when soaked in water. Break the piece into small fragments by using a hammer. As this operation causes the glue to fly about in all directions, it is an advantage to wrap the glue in a piece of thick brown paper or a clean duster before applying the hammer. Place the "bag" of glue on a hard surface, such as a stone floor, and hit it smartly several times with the hammer. After removing any fragments of paper or other extraneous matter which may have adhered to the glue, put the glue into the inner vessel of the pot. Cover the contents with cold water and leave it overnight to soak. This will cause the glue to swell. After straining off the water, partially fill the outer vessel with clean water (taking care to see that the water is absolutely clean, otherwise it will boil over) and replace the inner container. Put it on a lighted gas ring, and bring it gently up to the boil. Allow it to simmer for a time until the jellified glue has melted, stirring the mixture occasionally to remove lumps, and add more water as needed. Before use, remove any scum that may have formed on the surface.

Some glue pots have a notch in the lip of the water vessel to allow the steam to escape, others are not so provided. If you are using one of the latter, insert a match-stick between the lips of the containers, or, better still, file a notch when the pot is cold.

Before using the glue it is a good plan to stretch a wire across the centre of the container and fix the ends to the handle lugs. This arrangement allows any surplus glue on the brush to be conveniently removed by wiping the brush across the wire.

The glue is ready for use when it assumes the consistency of thin treacle. This can be tested by dipping the brush into the glue, holding it up over the pot and allowing it to flow back. If it flows from the brush in a steady easy stream, it may be taken as correct.

If you have never made glue before, and have plenty of time at your disposal a further test may be made which will enable you to judge its quality for future occasions.

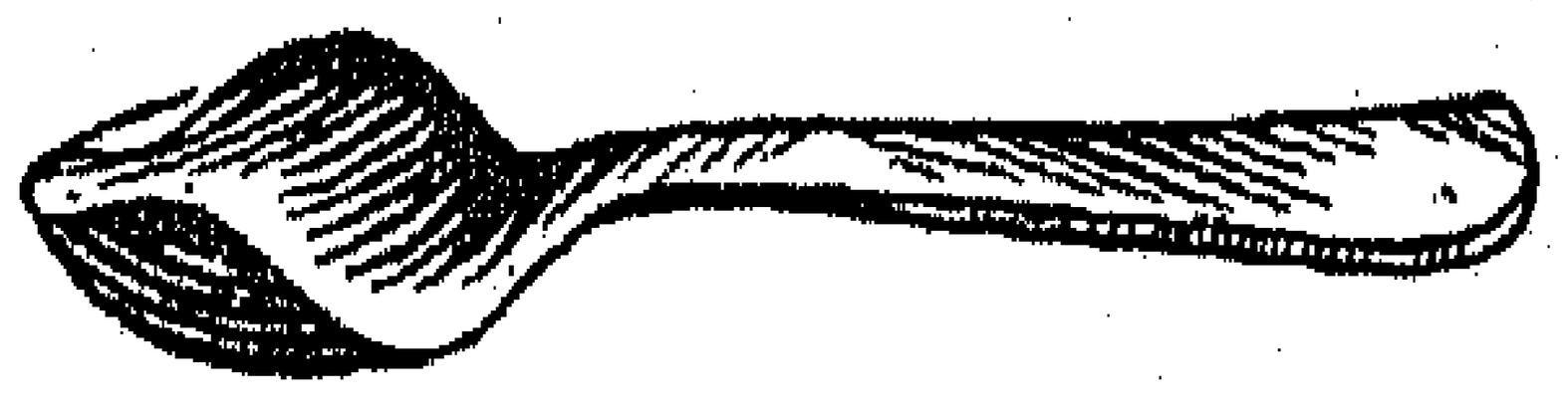


Fig. 2

Plane up the edges of two small pieces of wood, as in a butt joint, warm the pieces and apply a little hot glue to both surfaces. Rub the glued edges together and then cramp it up. Set aside for 24 hours in a warm room. If it breaks anywhere but at the glued joint after attempting to break the joint either by hand or by inserting the blade of a chisel into the end of the joint, you may be sure that the glue has been correctly made and properly used.

Glue Brushes.—Glue should be applied with a brush, the size of which depends upon the nature of the work. A paint brush about ½ in. wide will serve well for small jobs, such as gluing mitres of picture-frames and small mortices. A large brush should be employed on large work as the adhesive should be applied rapidly to prevent chilling, because chilled glue means an unsatisfactory joint. For this reason the work should always be warmed before applying the glue, and the process should be carried out in a warm room. When heating the wood be careful not to scorch or warp it.

Brushes after use should be washed in hot water to remove all traces of glue, and then allowed to dry.

It sometimes happens that a brush cannot conveniently be used for applying the glue, in which case the difficulty may be overcome by using an old teaspoon bent to shape as illustrated in Fig. 2. This forms a holder which, when filled with glue, can be poured into any odd corner of the work.

Cramps.—To ensure true fitting of the faces of the joint it is advisable to use two cramps as shown in Fig. 3. After the work has been cramped it should be placed flat down on an even surface and a heavy weight put on top.

Before fixing the cramps, however, any surplus glue adhering to the surface of the work should be removed by applying a rag dipped in hot water. This is a much better method than scraping it off, as it prevents damage to the surface, and ensures the removal of every particle of glue. This is particularly necessary should the work have to be stained or otherwise finished.

Reheated glue has not the adhesive power of fresh.

Liquid Glue.—If glue is only required occasionally, or if a small quantity is wanted, it will be found more economical and convenient to purchase a tube of liquid glue. The demand has reached such proportions that new makes of this form of glue are constantly appearing on the market. The prices vary considerably, but unless it is required for some important work the very cheap tubes sold at some of the numerous stores answer the purpose very well. A brush is unnecessary in applying the glue, as all that is necessary is to place the nozzle of the tube directly on the work and squeeze the bottom until sufficient adhesive is forced out. The glue may then be spread evenly over the surface with the forefinger.

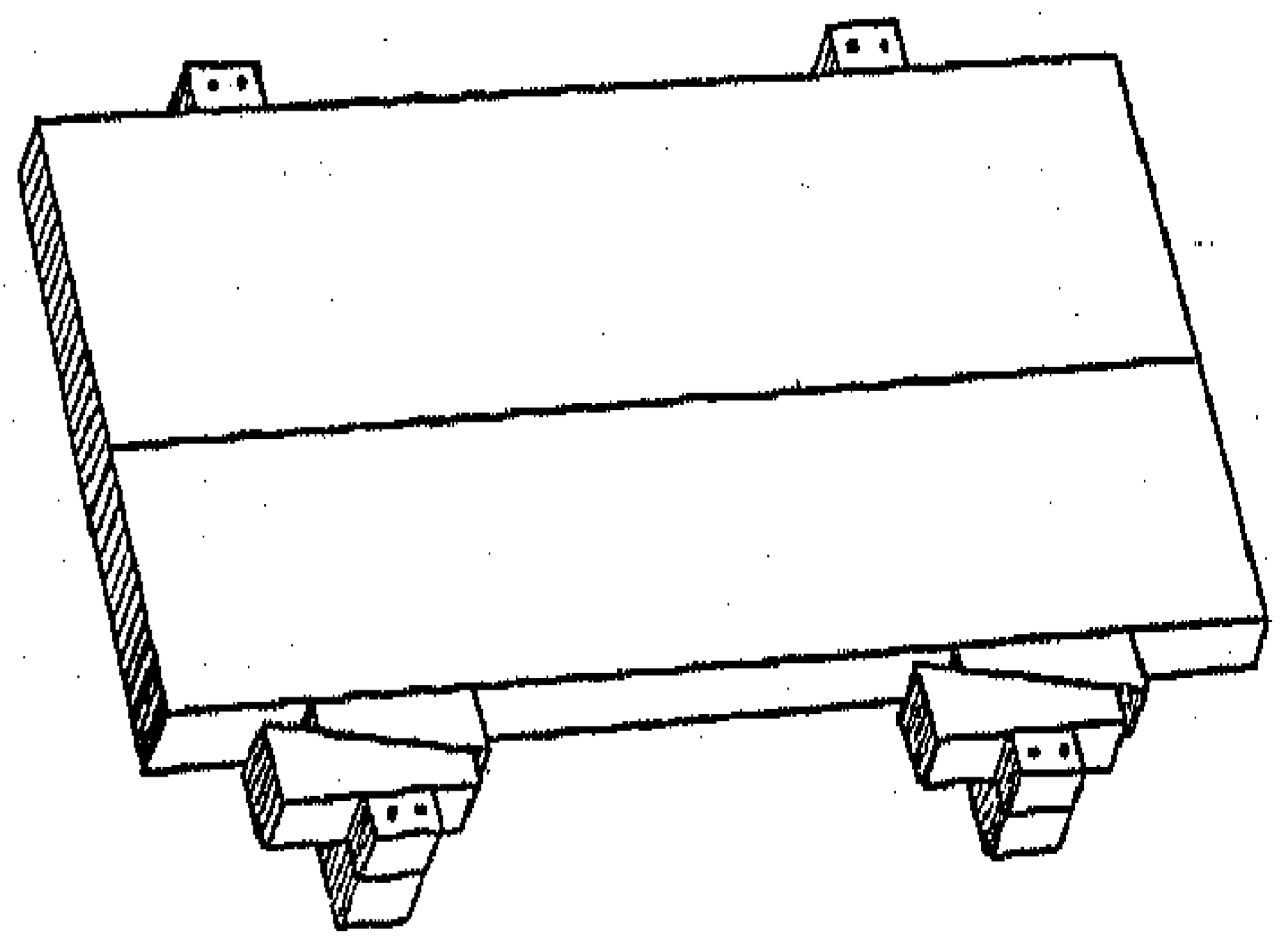


Fig. 3

Re-gluing Old Work is not always a pleasant job and cannot always be successfully carried out. It is useless to attempt to make a new joint by merely spreading glue over the old, putting it under pressure and hoping for the best.

The proper way to set about a re-gluing job is to remove the old glue first, using a sharp knife or chisel for the purpose, and then to wipe the surfaces with a cloth dipped in hot water. When the parts to be joined are perfectly dry they may be warmed, re-glued and put under pressure.

CRAMPS AND WEDGES

NEARLY all glued work is the better for being cramped whilst setting. This not only forces the parts together but it also defeats any tendency to break away whilst the glue sets.

Cramps are varied in form and are used for other purposes besides gluing.

An ordinary screw is in reality a cramp, but one left permanently in the job. It not only pulls the parts together but holds them in place.

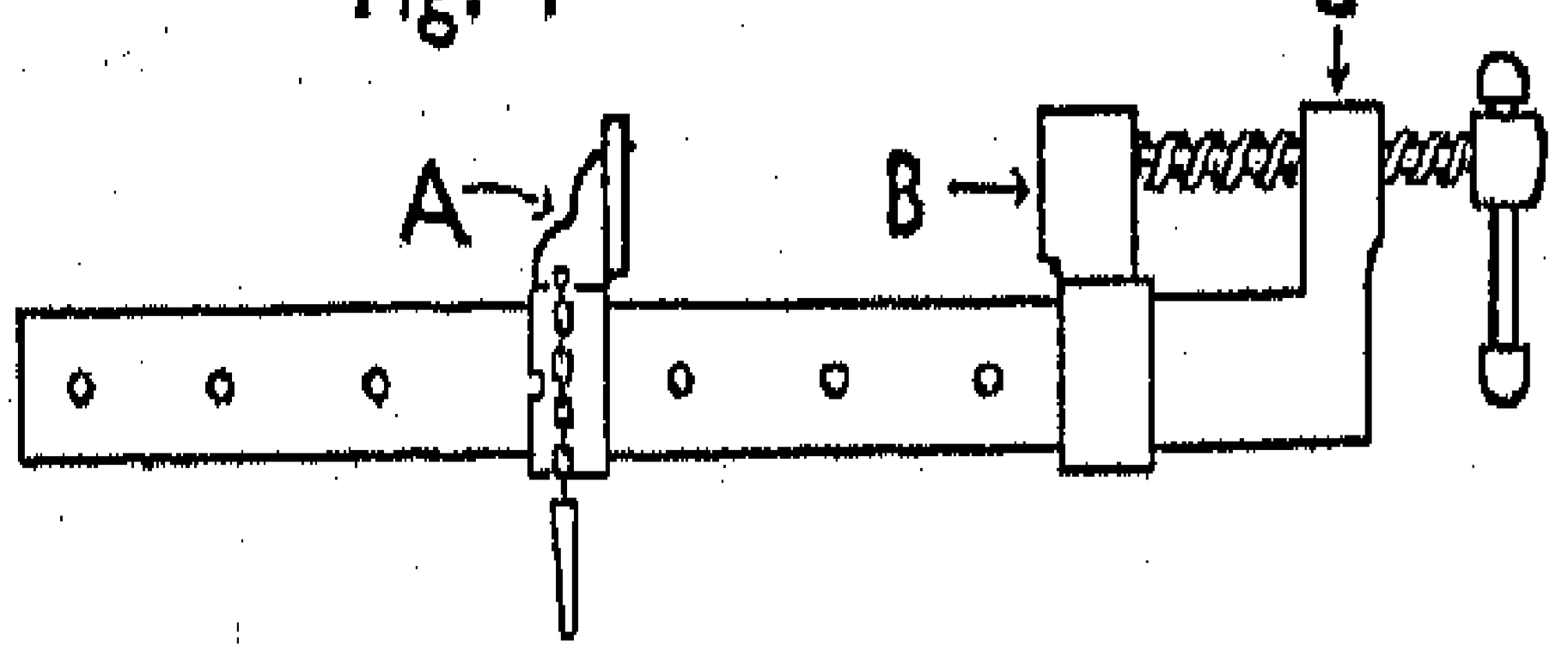


Fig. 1

A screw works on the same principle as an inclined plane and all cramps are based on this principle in one form or another—thus bought metal ones are fitted with a screw, while home-made clamping appliances generally rely upon the inclined plane in the shape of a wedge.

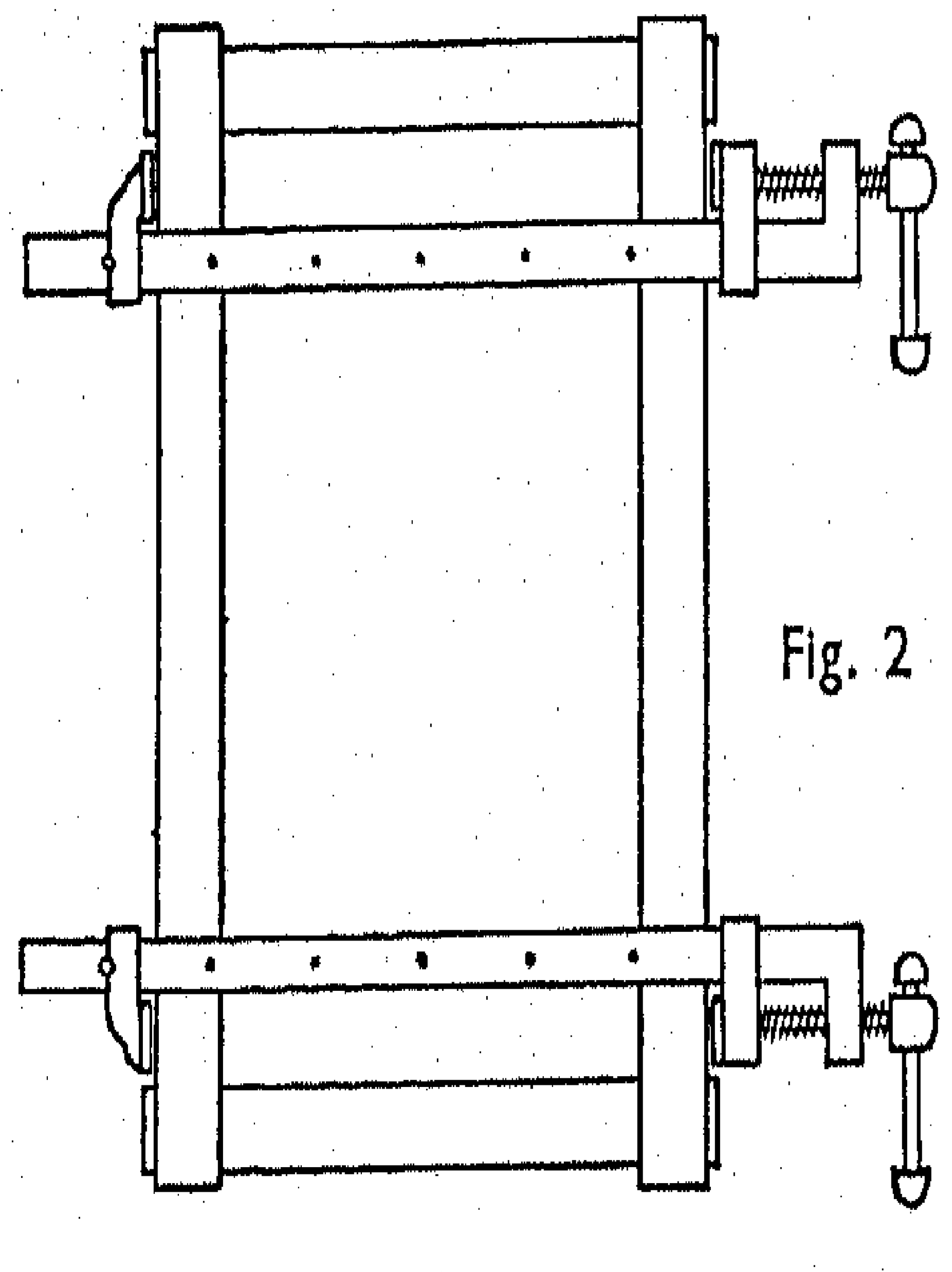


Fig. 2

The usual type of joiner's cramp (shown in Fig. 1) consists of a long bar, either of iron or mild steel, in which a number of holes are bored to take an iron peg that holds a sliding bracket A necessary to give the varying distances required. A second sliding bracket B, is worked by a screw passing through a fixed head C, at one end of the bar.

Two such cramps are usually necessary efficiently to cramp the work together. As joiner's cramps are rather expensive to buy, the cost generally precludes their use by the average home worker. The method of using such cramps is illustrated in Fig. 2, which shows a small door frame under treatment.

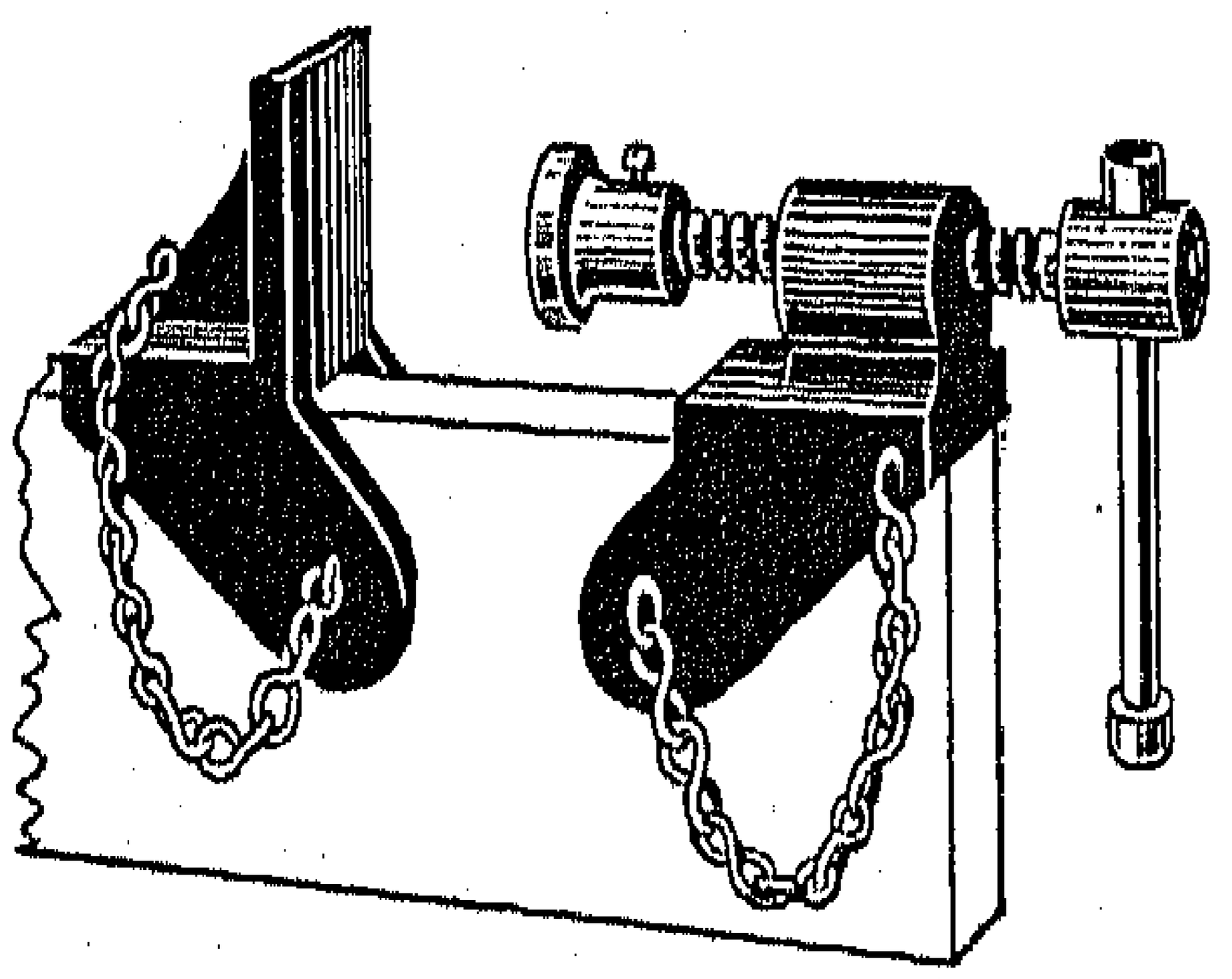


Fig. 3

Cramp-heads can be bought separately and will be found of great service to those workers who have a fair amount of cramping to do from time to time. The heads are provided with swivelling iron straps that bind on a suitable length of timber. Their usefulness is limited only by the length of wood used for the bar. As this type of cramp is comparatively cheap it should appeal to the handyman. Fig. 3 shows this useful device.

The majority of work needing the use of cramps can usually be done by cramps made of suitable lengths of wood, with wedges to replace screws. They can be easily and quickly made of odd pieces of wood generally found in every workshop.

A typical example of a home-made cramp suitable for cramping, say, a small frame measuring 18 in. wide, is shown at A in Fig. 4. Such a cramp can be made from a piece of board, 2 ft. or more in length, 4 or 5 in. wide and $\frac{7}{8}$ in. thick, by screwing a cross-piece flush with one end of the board, and another at a distance of 19 in. away. This leaves a gap of 1 in. between the work and the cross-pieces for the insertion of wedges.

The two wedges shown at B are prepared from a piece of rectangular wood $\frac{7}{8}$ in. thick, by cutting it across diagonally. The wood for these should be straight-grained, and the taper should only be sufficient to obtain the compression desired. If angles are made too obtuse they may work loose.

If the frame is fairly long, it is advisable to use two cramps; they should be fitted as close as possible to the mortice and tenon joint of the framework.

An improvement on the home-made wooden cramp just described is shown in Fig. 5. The illustration needs no description as it is self explanatory. If much use is going to be made of the device with boards of varying thickness, the following alterations are advisable.

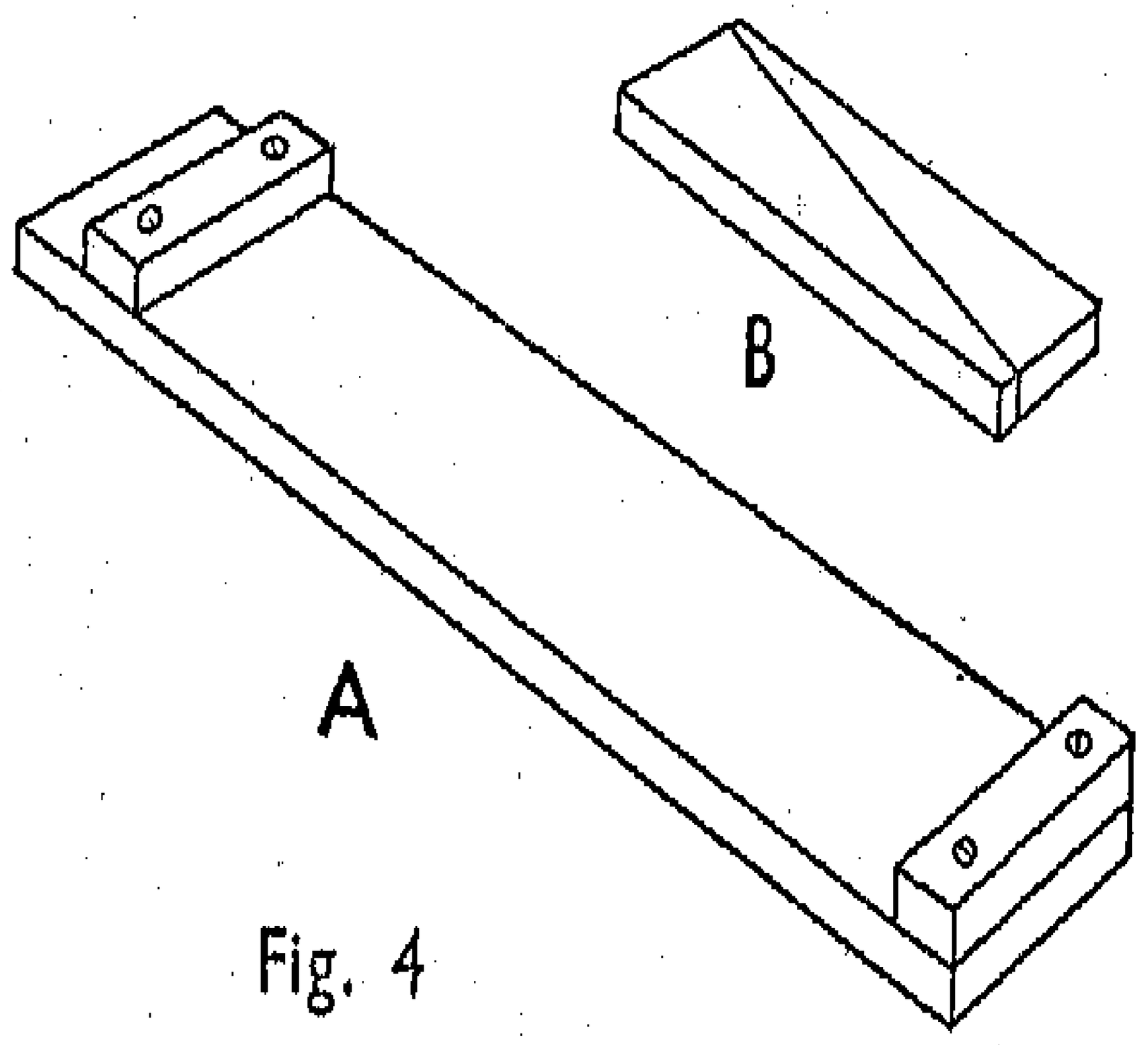


Fig. 4

Make the two inner blocks (A) slightly thicker than the work to be wedged, and fix them to the outer members by means of bolts and wing-nuts, not forgetting to insert large iron washers between the heads of the bolts, nuts and wood.

The advantage of using this type of cramp is that the work is supported on all sides, and any tendency to rise at the joints is prevented by the side members.

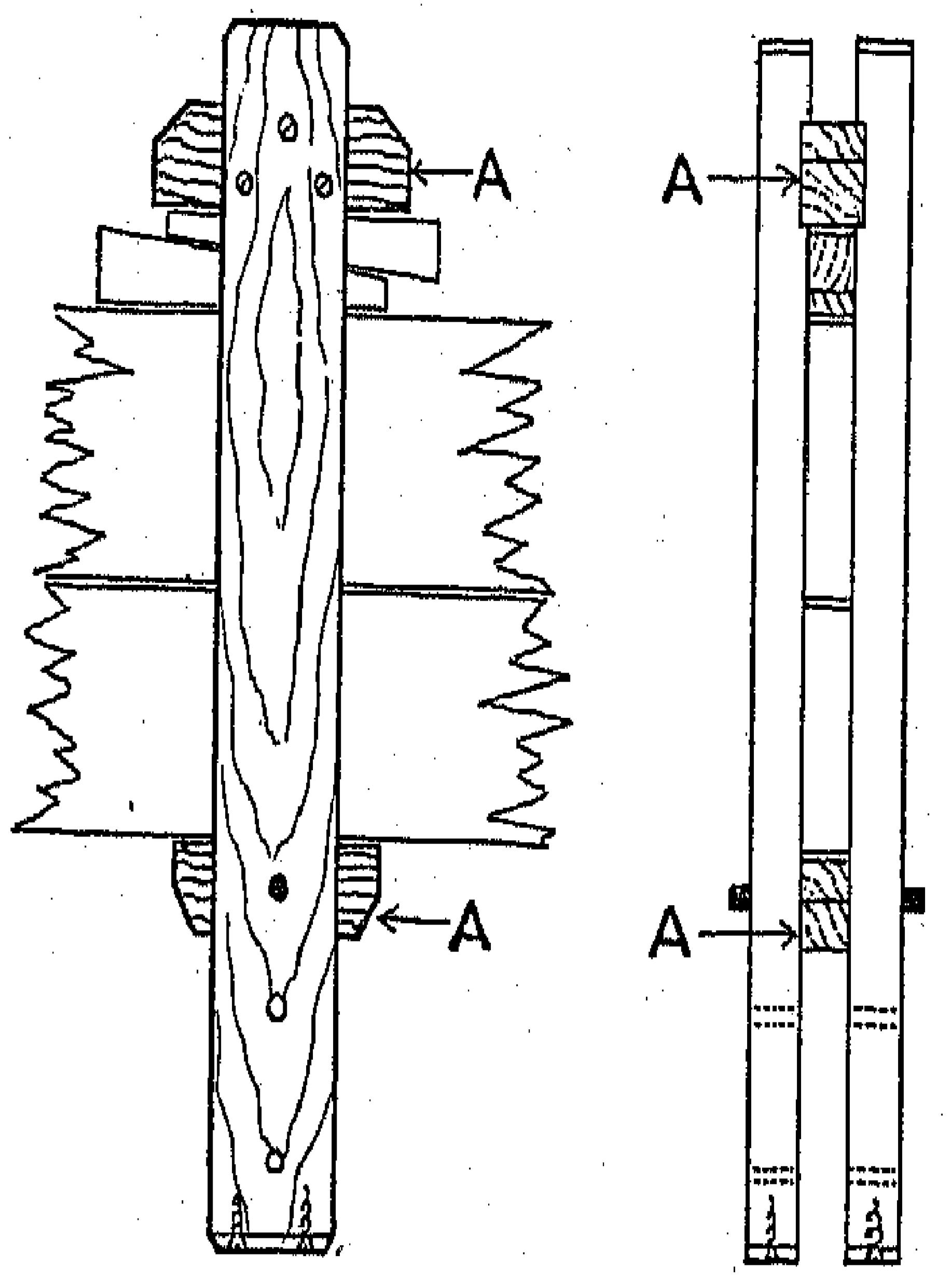


Fig. 5

In cases where short boards are to be cramped, the edges to be joined should be very slightly planed hollow. If this is done, a single cramp in the middle would suffice, as the slight concavity causes the ends of the boards to meet at once, and any pressure in the middle binds them together.

To keep the ends of the boards true laterally, a joiner's "dog" (illustrated in Fig. 6) may be called into requisition; or, if the boards are not thick enough for these, a corrugated nail driven partly home will usually answer the purpose.

A Cramping-board made on similar lines to that shown in Fig. 7 will be found very useful for cramping small work. A cheap pastry-board could be used for the base if it is not thought worth while to make one. Two accurately-planed strips of wood are either nailed or screwed at right angles to each other to the base, and two similar strips are fastened down at a slightly greater distance from the others than the length and width of the frame to be cramped.

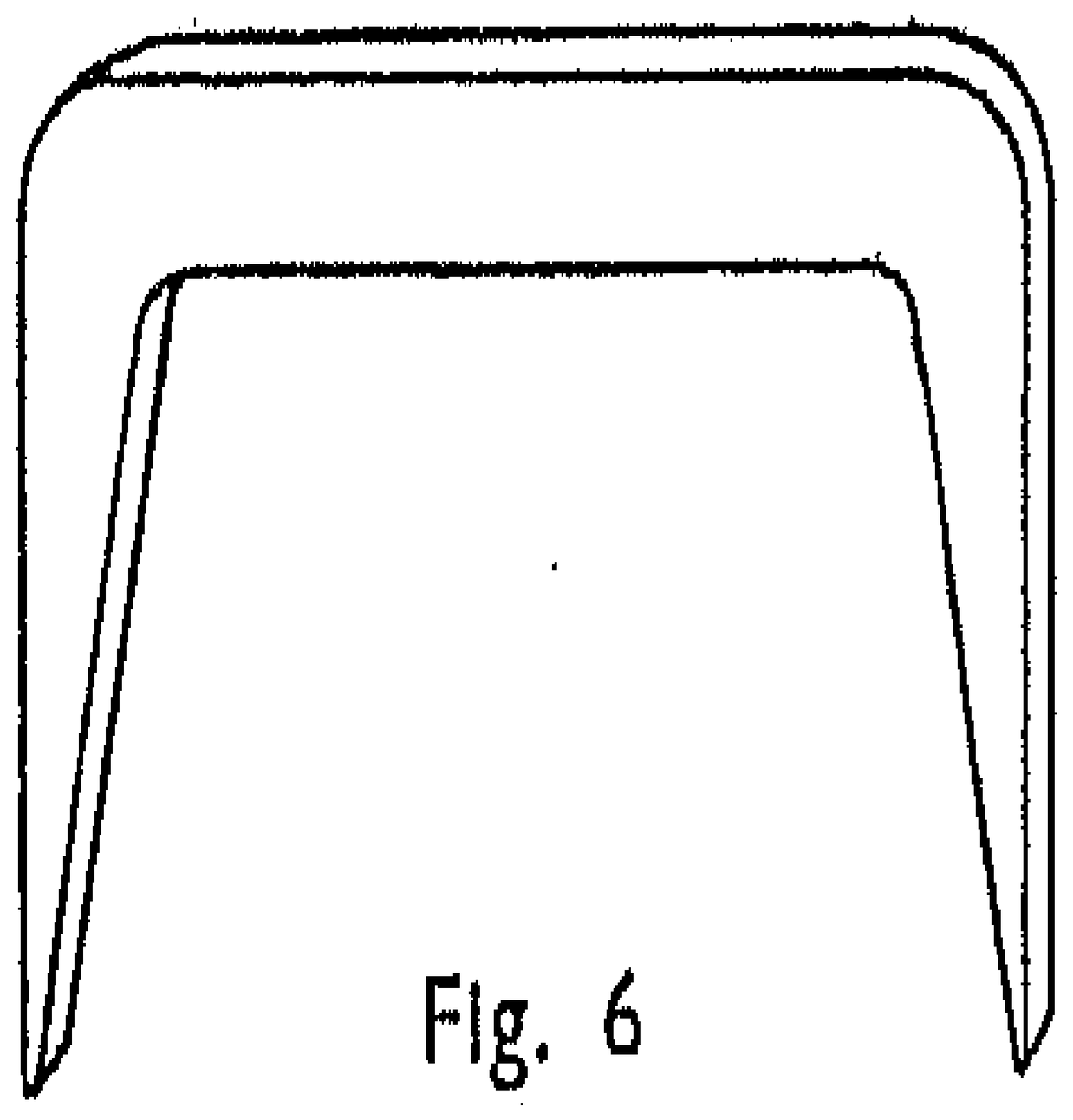


Fig. 6

The strips need not be as long as either the length or width of the frame.

The frame to be cramped is glued and assembled, one corner is inserted into one of the angles formed by the two strips, and wedges are driven between the frame and the other strip, which cramp all up tightly.

In making the device, care must be taken to fix the pieces at right-angles. Always test them with a square.

Cramping Floorboards. — While dealing with the subject of cramps it may not be amiss to give a method of cramping up floorboards, especially if a new workshop or other structure is in course of construction.

The tradesman generally uses special cramps for the purpose, but the amateur can cramp floorboards in the following way.

Nail down the first board, and at a distance of about ¼ in. less than the width of 4 or 5 boards, nail down a second board. Place the loose boards, with their edges butted together, in the intervening space. The middle joints will be raised, but by standing on them, the boards will be forced into place. It may need more than the weight of one person to do this. This method answers very well if each board extends the whole length of the floor.

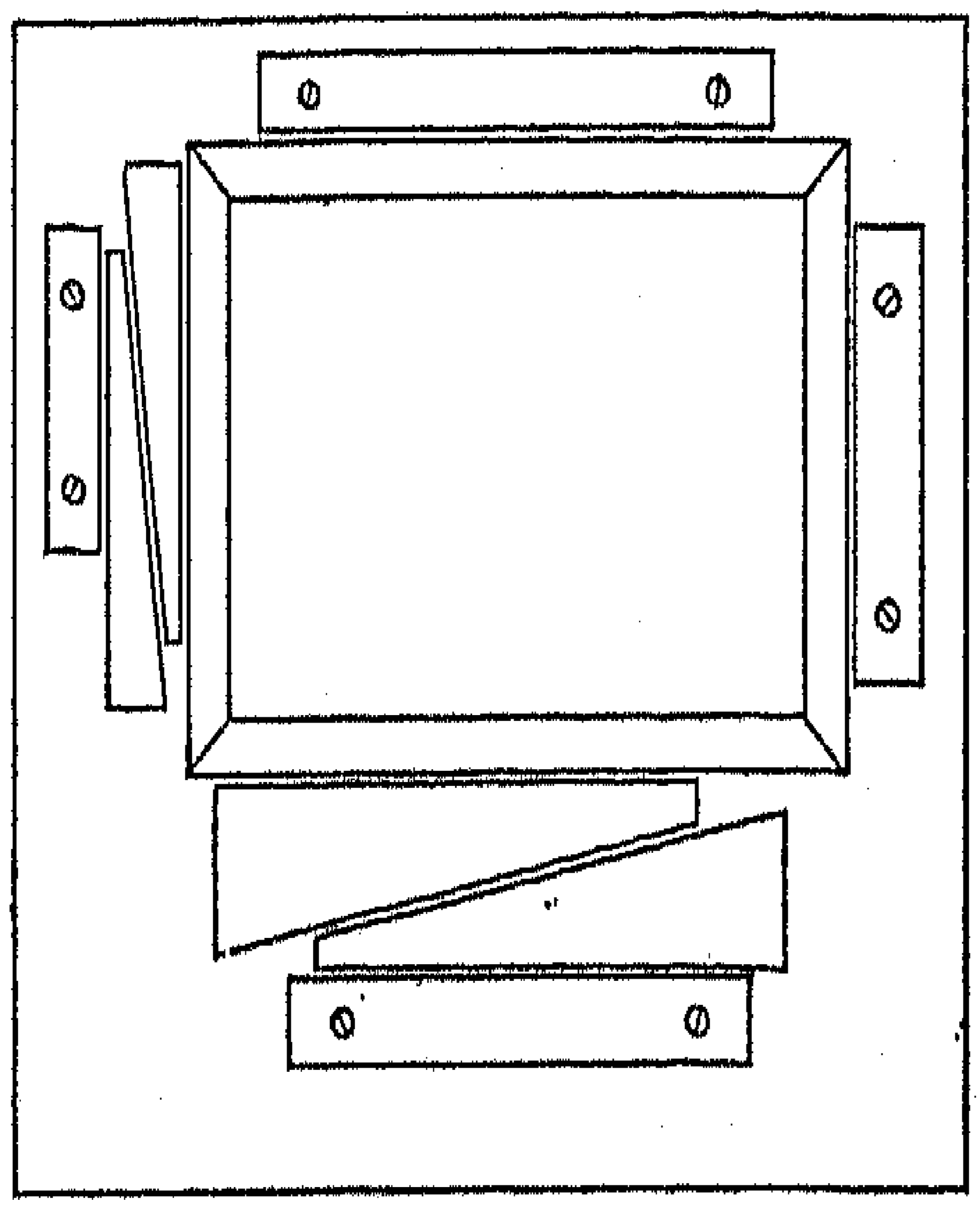


Fig. 7

GLASS-PAPERING

GLASS-PAPER is used principally for putting a final finish to the surface of wood where the plane has not left it as smooth as could be desired.

It is made by sprinkling powdered glass over the glued surface of tough paper by means of sieves having from 16 to 90 meshes per inch.

Fine, medium and coarse glass-paper are the grades commonly used by the amateur. No. 0 is the finest, and is employed for producing a fine finish; No. 2 is coarse and therefore suitable for rough work.

Glass-paper is sold in sheets measuring 12 in. by 10 in., and can be obtained with a cloth backing instead of paper, which gives it exceptional strength. It can also be obtained with a waterproof backing which renders it invaluable for rubbing down paintwork with water.

In using glass-paper for finishing the surfaces of wood it is usual to start with a coarse grade and to finish with a fine, but this does not always apply, because much depends upon the finish desired.

When preparing work that is to be either french polished or varnished, the glass-paper should be rubbed along the grain of the wood, as any scratches left on the surface will show through the more or less transparent film of polish. This is not so important where the work is to be painted, as the paint will cover up any such imperfections. In fact, it is generally an advantage to glass-paper across the grain at an angle of about 45° when paint is used, as this makes for quicker finishing.

Flat surfaces treated with glass-paper should be kept flat on the work by means of a suitable rubber.

These appliances can be purchased at a cost of only a few pence, but one can be easily made by the worker himself from a piece of flat wood 4 in. in length, 3 in. wide, and ¾ in. thick. The bottom of the rubber is then faced by gluing on a piece of cork, such as that commonly used for teapot stands, or a piece of thick linoleum.

If cork is used, cut it with a wet knife, as when cutting rubber.

The Block can be used by folding the ends of the glass-paper over the sides and keeping it in position with the fingers.

A much better device for holding the glass-paper is that illustrated in Fig. 1, which, although not quite so simple to make as the plain block, is well worth the little extra time required for its construction. Reference to the illustration shows that it consists of two parts. A strip of glass-paper is held between the top and bottom members, which are fastened together by means of a 1¾-in. by $\frac{3}{16}$-in. Whitworth bolt fitted with a wing-nut.

The block is made in the following way. Get a piece of wood, preferably hardwood, and plane it up to a finished size of 5½ in. by 2½ in. by 1¼ in. Round off the top long edges and form a hollow in the sides by means of a gouge. The hollow is not absolutely necessary but it enables the block to be conveniently held. Bore a 1¼-in. diameter recess, ½ in. deep, in the centre of the top face, using a centre-bit for the purpose, and drill a small clearing-hole through the centre of the recess to take the bolt.

The finished size of the bottom piece is the same as the top except that its thickness is only ½ in. Make a $\frac{3}{16}$-in. diameter hole through the centre, and cut a small recess round the hole on the bottom face to take the head of the bolt and allow it to lie flush or just below the surface. Now drive the bolt through the hole by giving it a few taps with a hammer. The bolt will be prevented from turning when the nut is fitted by the small square shoulder under the head of the bolt. Glue either a piece of lino or cork on the bottom and allow the glue to dry. Cut a strip of suitable glass-paper, 10 in. in length and 2½ in. wide; insert the ends between the top and bottom pieces of the block and pass the shank of the bolt through the hole in the top member. Slip an iron washer over the end of the bolt and

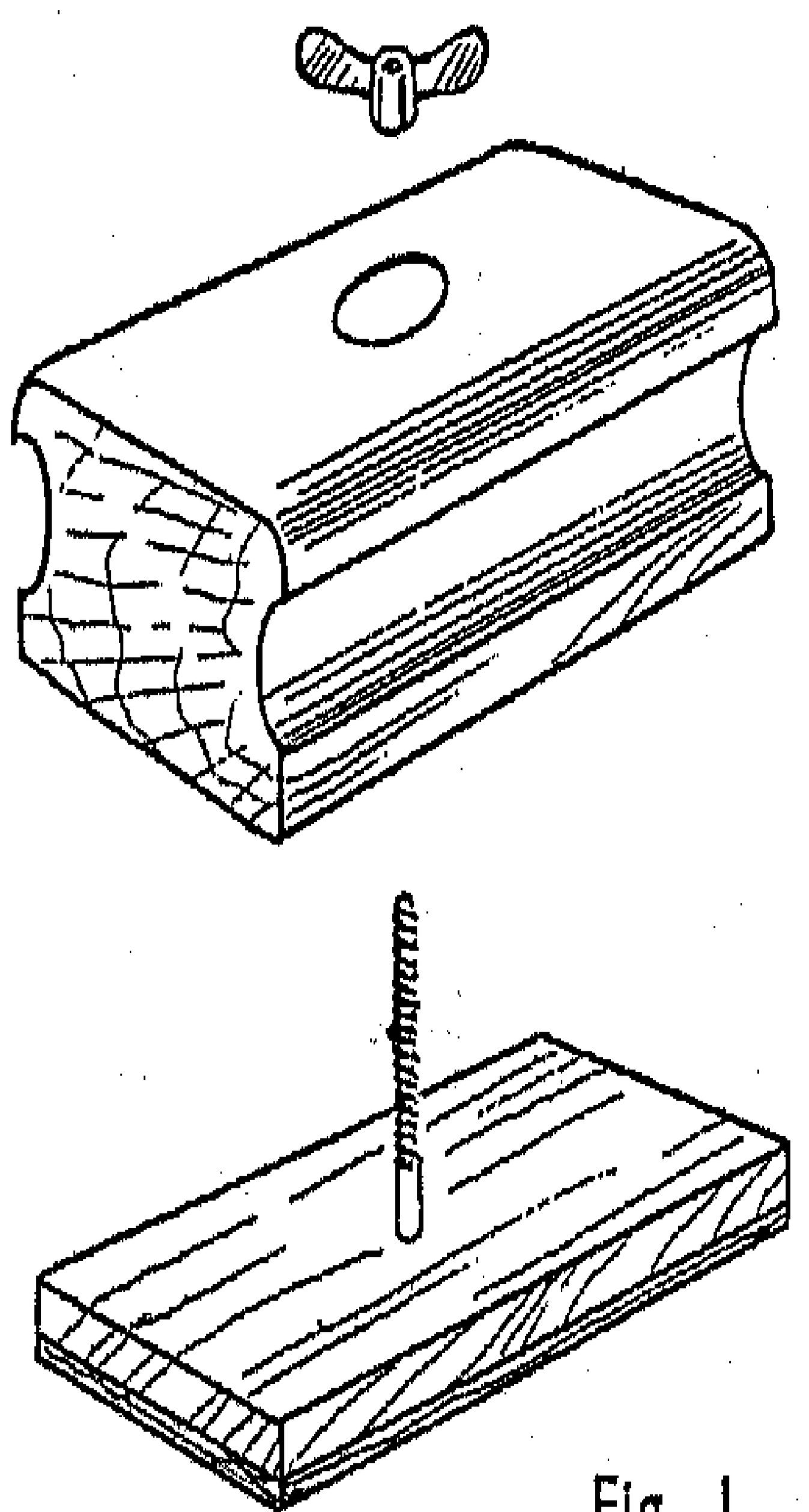


Fig. 1

tighten up the parts by means of the wing-nut. Fig. 2 shows the block in use.

When glass-papering concave-shaped surfaces such as hollows in mouldings, etc., it is an advantage to wrap the glass-paper round a suitably shaped piece of cork or wood. For treating convex surfaces a hollowed piece of wood is a great help. (*See* Fig. 3.)

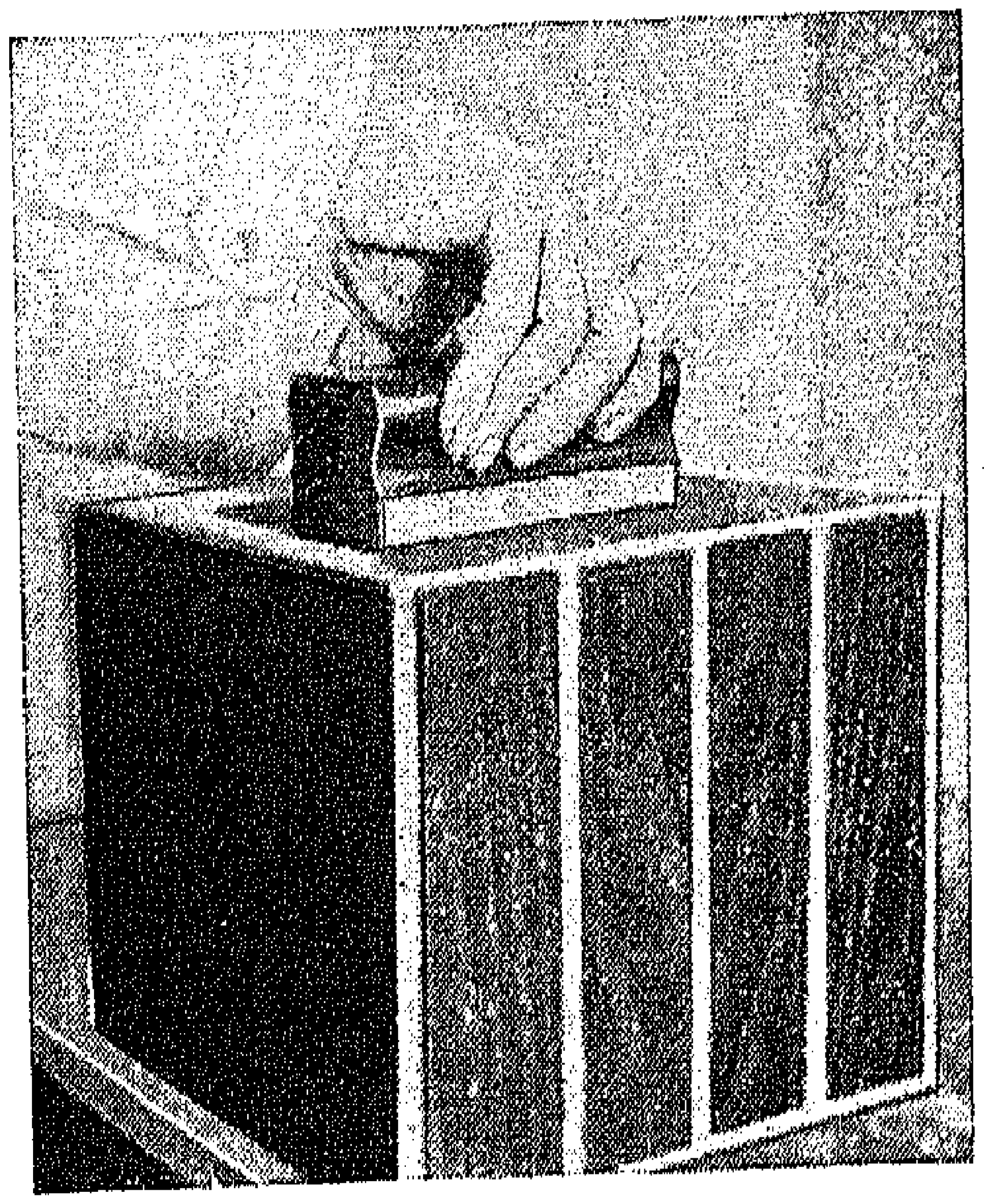


Fig. 2

The marks left on the flat surface of hardwood after planing are generally removed by means of a scraper before finishing the work with glass-paper.

A Scraper is merely a piece of steel about $\frac{1}{16}$ in. thick and 5 in. long by 3 in. wide, and can be purchased from most tool-dealers for a few pence.

Scrapers may be obtained with curved surfaces to fit various curved work such as mouldings, etc., but they are more costly than the rectangular ones.

The properly-sharpened scraper becomes an efficient tool and does not just scrape as its name suggests, but acts as a very finely-set plane. This makes it particularly useful for negotiating irregular grained hardwoods, where the use of a plane generally tears the fibres.

The cutting action is effected by turning the long edges over to form a "burr," as shown enlarged in Fig. 4, and the secret of successful scraping depends in no small degree upon how well the burr has been formed.

In use, the tool is usually held at the ends by placing the thumbs at the back and the fingers at the front in the manner indicated in Fig. 5. It is held at an angle of about 60° to the surface of the work in the same way as a plane-iron is fixed at an angle in the stock.

Some workers prefer to push the tool forwards—in the direction of the grain, of course—while others pull the scraper towards them. It is sometimes a help to hold the tool a little obliquely instead of at right angles to the direction of scraping.

If the tool fails to do its work properly it should be sharpened. The formation of dust instead of tiny shavings is generally a sure sign of a blunt tool.

The scraper is regarded by many as a difficult tool to sharpen. This may be due to their lack of knowledge regarding the working principle of the tool, or it may be that they do not go about the work in the correct manner.

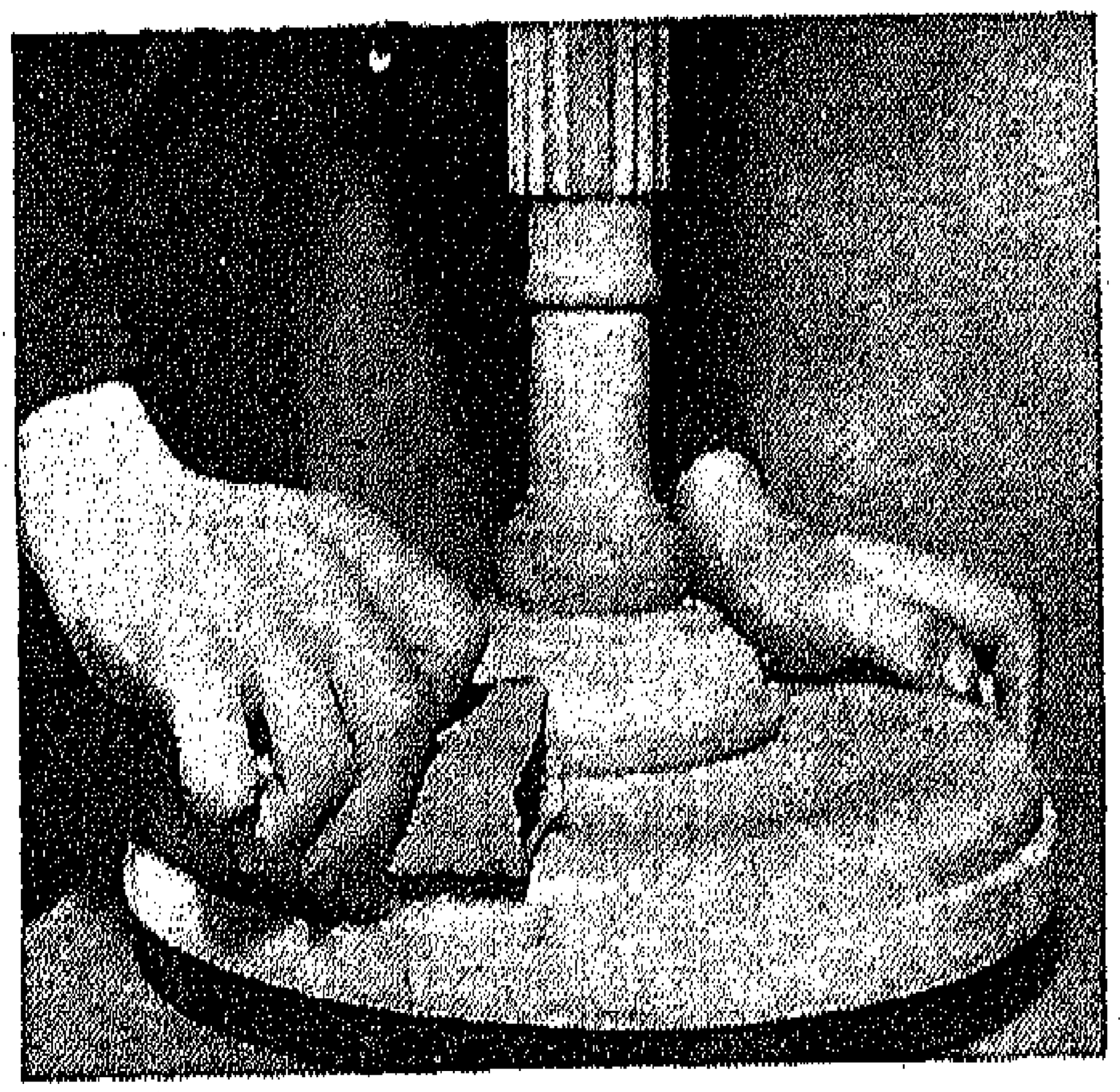
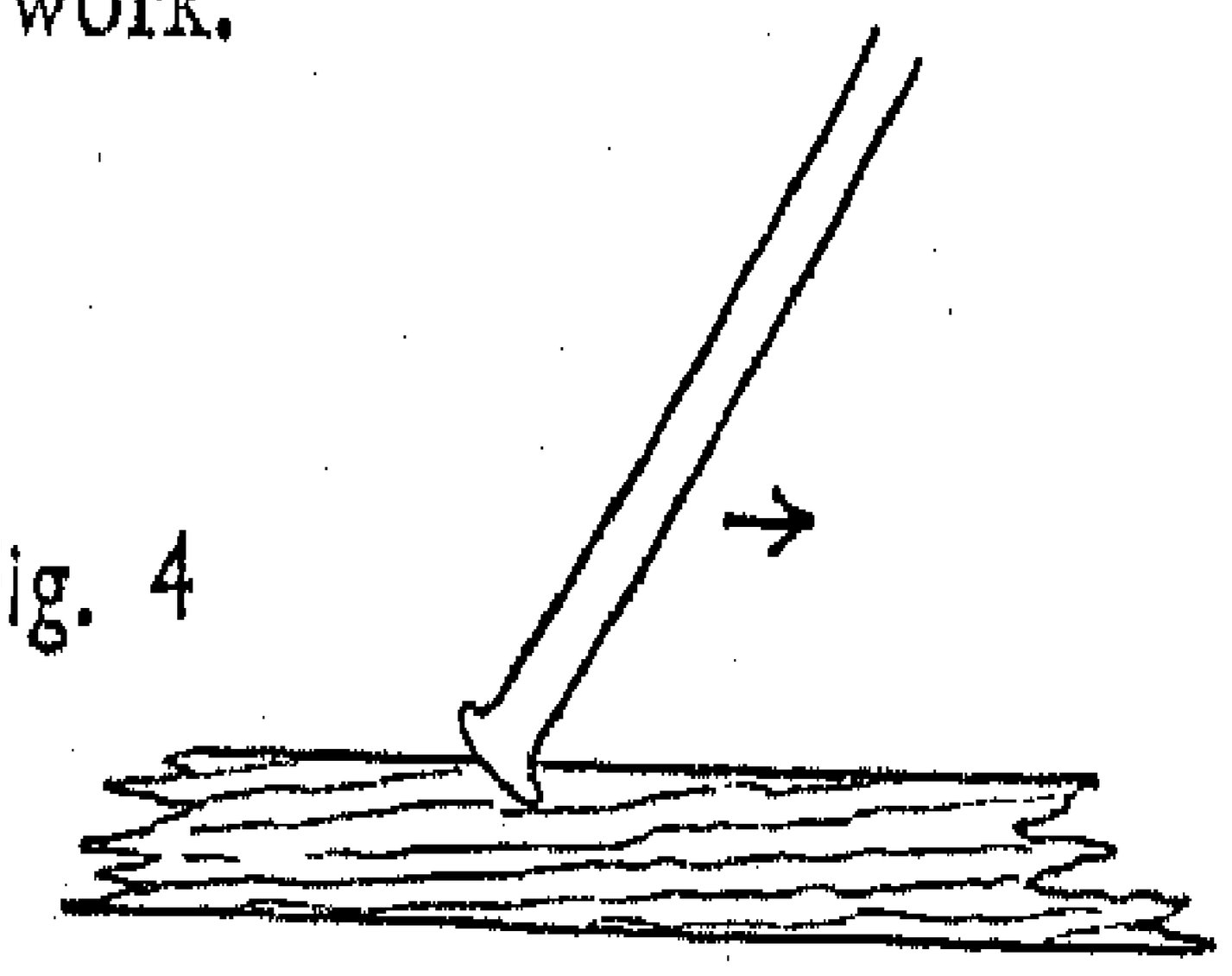


Fig. 3

To Sharpen a Scraper, place the tool, working edge uppermost, in the vice, and file the edge perfectly clean and flat, using a fine flat file, held lengthways, for the purpose. Test with a square, and if there is any trace of hollowness or other irregularities, repeat the operation until a perfectly true flat face is obtained. Just touch the two corners with the file to round them slightly and prevent the corners scoring the work.

Fig. 4


Now fix the oilstone, long edge upwards, in the vice in the manner shown in Fig. 6. Rub the edge of the tool several times up and down the side edge—now the top—to remove the marks left by the file, using the wooden edge of the case as a guide. The burr thrown up at the edges by the file must now be removed by placing the working end of the blade flat on the oilstone, and giving it one or two rubs across the surface. Turn the tool over and repeat the process on the other side.

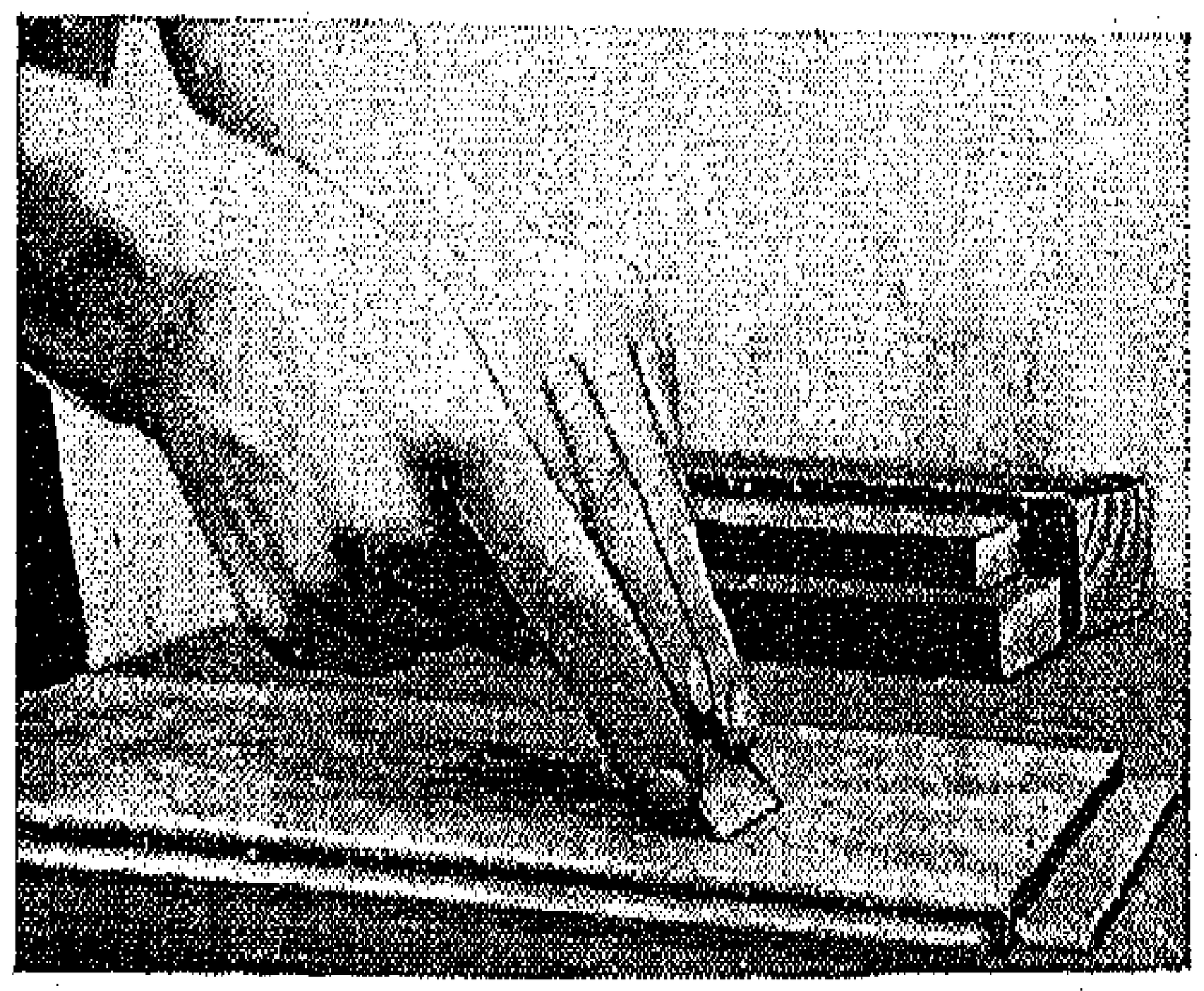


Fig. 5

It is of the utmost importance that the foregoing preliminary operations be carefully carried out, because the better they are done the smoother the scraper will work.

Turning up the Burr.—Hold the scraper flat on the bench with the left hand, allowing the prepared edge to overlap the edge of the bench by about $\frac{1}{8}$ in. Now rub back and forth along the edge of the tool several times with either a piece of round hard steel or the back of a gouge, applying heavy pressure during the process, to turn up the burr. Reference to Fig. 7 will show you exactly how this is done. When rubbing the edge, keep the handle of the sharpener down to give the burr the necessary angle. When one edge is finished, turn the blade over and work the other edge in the same way.

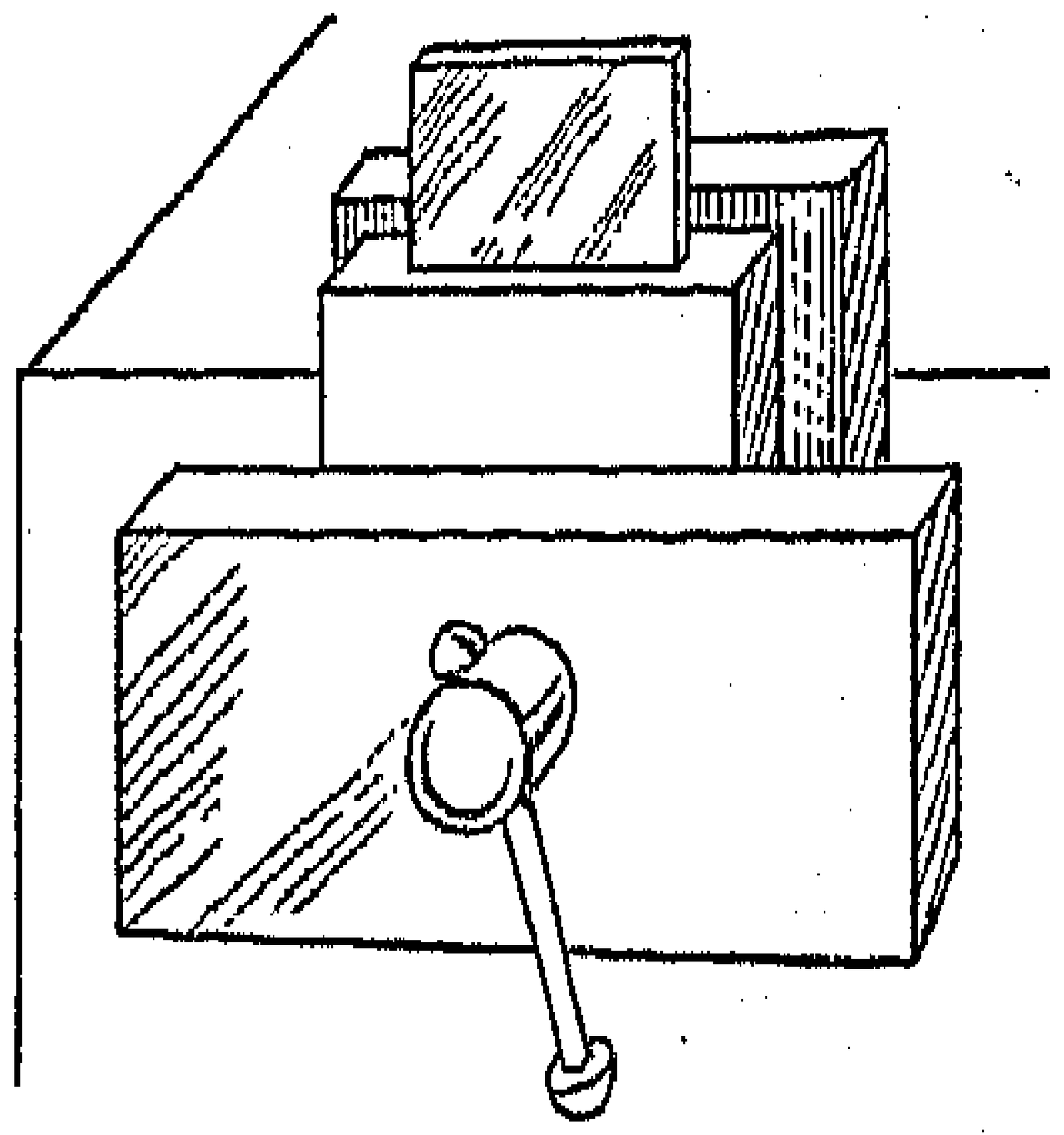


Fig. 6

It should be noted that if the tool has been allowed to get badly pitted with rust it is better to discard it, as an efficient edge cannot be produced and good results will be impossible.

A cleanly cut piece of window-glass is a good substitute for a metal scraper, and generally answers the purpose perfectly. If it is held at an angle of about 60° to the surface of the work it takes off a nice clean "shaving." Before using, it is a good plan to remove the corners of the working edge by rubbing them on the oilstone.

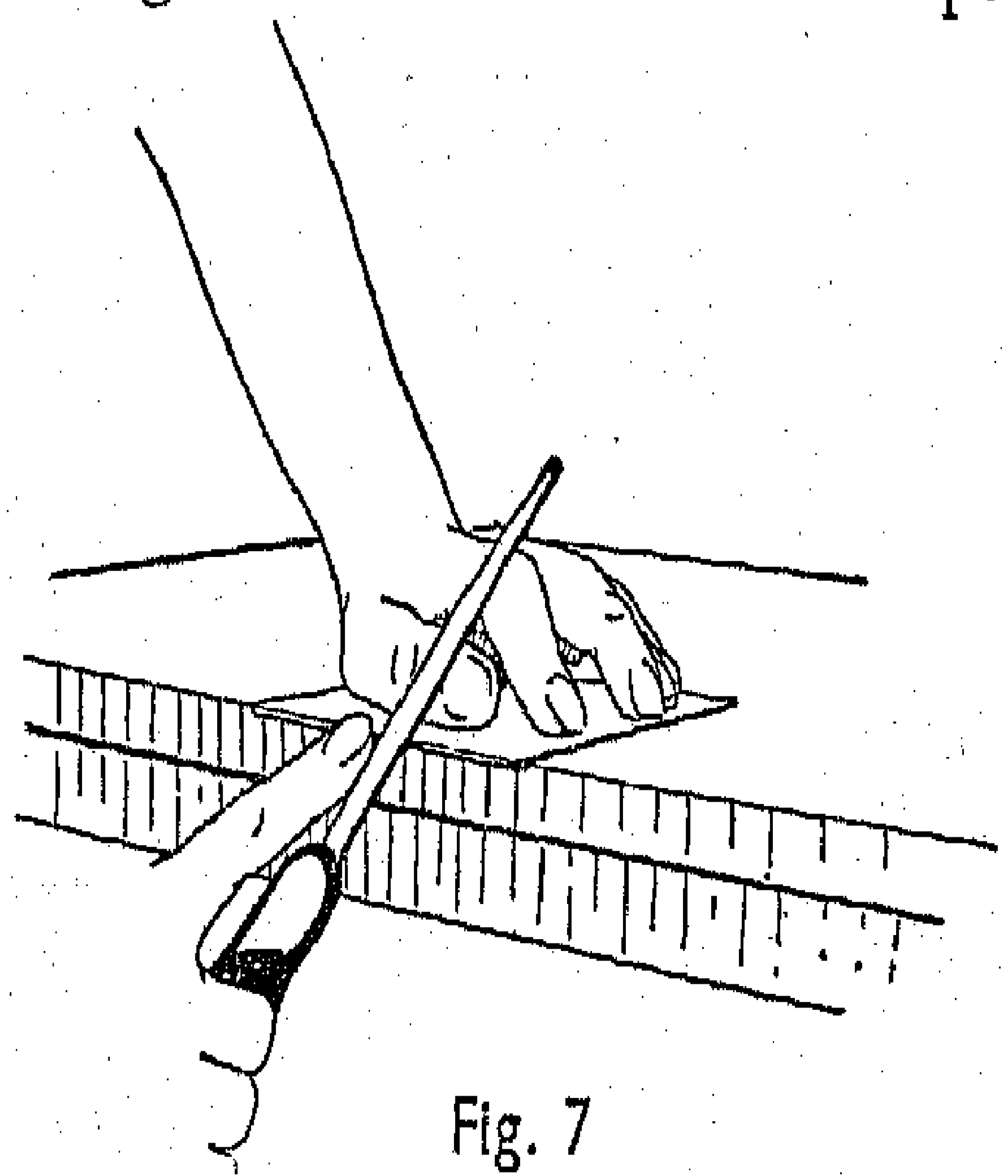


Fig. 7

WOOD FINISHING

Wood that has been used for any construction work is rarely left in its natural state but is "finished," as it is called, and this finishing consists generally in applying some coating protective or decorative, or both.

The commoner varieties of wood, including most softwoods, generally receive a protective coat, although before any such medium is applied the wood should be thoroughly seasoned.

Softwoods are generally painted, creosoted, or stained and sometimes varnished, while hardwoods of the more expensive kind are usually french polished.

Paint or other protective mediums are useless if applied to unseasoned wood, because they merely fill up the outside pores and confine the moisture in the wood, which causes it to rot.

Thus, the practice of tarring the bottoms of posts that are to be put into the ground is little better than useless if cracks are open or likely to open to allow the wet to enter the substance of the post.

A better procedure would be to put the bottom portion of the post into a metal container such as a dust-bin, or an old milk churn, partially filling it with creosote and then boiling it for about twenty minutes or so.

Painting is generally adopted for covering the commoner varieties of wood such as deal, spruce, etc., as paint if properly applied has both decorative and protective properties.

Before actually applying paint to new wood, the surface to be covered must be subjected to certain treatment, and the first and most important item is to see that the material is perfectly dry.

All holes and cracks should be "stopped" with a "filler." There are many wood fillers on the market, but for paint work the commonest is putty. Putty can be either made at home or purchased. It is made by mixing ordinary ground whiting with linseed oil and then kneading to form a plastic mass. Care must be taken when buying linseed oil to get the best quality, as a common grade has poor drying capabilities, with the result that it often works its way through the coats of paint and leaves an unsightly stain. This fault is particularly emphasised when white or any light-coloured paint is used.

As putty will not adhere to bare wood, it is applied after the first or "priming" coat of paint has been finished and allowed to dry. The reason for this is that the oil in the putty is absorbed in bare wood and consequently leaves a quantity of whiting only, which either flakes off or simply crumbles away.

A Useful Filler for bare wood can be made out of sawdust mixed to a thick paste with glue or gold-size. This compound will be found particularly useful for filling defects in hard or fancy woods, as the sawdust of the actual wood can be utilised.

Recently another form of filler has appeared on the market. It is known as plastic wood, and can be obtained in either tins or collapsible tubes. For the infrequent user, the latter is much to be preferred, as it not only means a smaller initial outlay, but the tubes are almost self-sealing and therefore exclude the air. If, however, a large amount of "stopping" has to be done, it is more economical to buy a tin; but the cover must always be refixed as soon as the material is withdrawn, because plastic wood loses its pliability when exposed to the air.

The special benefit obtained by the use of plastic wood is that it cannot be distinguished from the wood on which it is used. To use the preparation, all that is necessary is to fill the hole or crack by applying a small quantity in excess of the actual quantity required for filling the crevice; when dry, use fine sand-paper to level the surface. Plastic wood shrinks slightly and dries very rapidly.

Knots in wood present another difficulty to the painter. They exude turpentine and resin, or, on the other hand, they absorb the paint, leaving ugly marks on the finished surface. The knots are, therefore, "killed" by painting them over with "patent" knotting, which is a preparation of shellac and methylated spirit. Ordinary french polish or shellac dissolved in methylated spirit usually answers the purpose.

Paint is composed of a basic pigment consisting generally of either an oxide of lead or an oxide of zinc, a pigment to give the desired colour, and linseed oil and turpentine, to which is added a small quantity of "driers" which helps the paint to dry and harden.

The first coat of paint applied to the wood is called the "priming" coat, and should consist of a mixture of red and white lead, and either boiled or ordinary linseed oil. It is mixed in suitable proportions to allow it to dry quickly, and, if properly prepared, also helps the following coat to dry.

A good priming coat for outside work can be made as follows. Add ½ pint of raw linseed oil and the same quantity of boiled linseed oil to 4 lb. of white lead and ½ oz. of driers. Stir well and strain before use.

The time required for paint to dry depends to some extent on the temperature of the atmosphere. It oxidises rather than evaporates, so a good supply of warm fresh air would help to quicken the process.

If the paint thickens, its more liquid consistency may be restored by the addition of either turpentine or linseed oil—boiled oil in preference for exposed positions. Sometimes it is advisable to use both, as "turps" in excess dulls the surface and affects the durability.

Some paint manufacturers advise a special thinning compound of their own make to suit their paint which, when specified, should always be used.

As mentioned before, wood should always be in a dry condition before painting is attempted. If damp, the moisture is kept enclosed by the coat of paint, and the heat on a warm day vaporises it, causing blisters to appear. Surfaces that have had previous coats of paint burnt off are dried by the heat of the blow-lamp, consequently paint applied to the treated surface rarely blisters.

Painting.—No advantage is gained by brushing the paint on too thickly, and the idea that one thick coat is equivalent to two thin ones is a fallacy. Thin coats, properly applied, and the judicious use of sand-paper between each coat when thoroughly dry are the determining factor of a good final finish.

Sometimes the final coat is mixed with varnish to add brilliancy, or the last coat of paint is varnished afterwards. In both cases the previous coat must be thoroughly dry and hard; otherwise cracks will appear later.

It may be pointed out here that when a glossy finish is required, the previous coats must be carried out with a "flat" paint—that is a paint which dries without gloss.

Enamel or hard gloss paints are now obtainable. Some are specially prepared to withstand the effect of boiling water and are sold under the name of bath enamel. A coat of this applied to the wood, if carried out in a warm room and the enamel paint itself kept warm in a hot-water bath, produces a delightfully smooth and glossy effect. The finish may be to some extent compared to the stove enamelling used for finishing bicycles. One cannot, nor would it be advisable to, stove articles of wooden manufacture, as they would in all probability twist and shrink out of shape.

When a painted surface is intended to be for decorative as well as preservative purposes, "graining" and "marbling" is often resorted to.

Graining requires special tools to mark the final coat of paint, called the graining coat, which is painted to represent or imitate a particular kind of wood such as ash, oak, maple, etc.

Marbling is the process used to imitate natural marbles, and bears a close relationship to graining in the imitation of woods. Transfer papers can be obtained that enable one to produce these effects without having to rely on skilled workmanship.

Another popular medium for the artistic finishing of wood is found in cellulose brushing lacquer, of which there are numerous makes now on the market. This useful material can be obtained in various colours at most colour stores. It is applied with a brush like ordinary enamel. The advantages gained by using cellulose lacquer are that it dries very quickly without leaving any brush-marks, and produces a beautiful, glossy and durable surface.

Generally speaking, the number of brushes required for painting woodwork depends upon the nature of the work. For painting narrow surfaces a "sash tool" is the correct brush to use, but when larger surfaces are to be covered, a larger tool called a "ground brush" is generally employed.

It always pays in the long run to get a good brush. One bound with metal and rubber is much to be preferred to the more or less old-fashioned brush having the bristles fastened in with glue. Before using a new brush always soak it in water for two or three hours to prevent the bristles from becoming detached—a common occurrence if this precaution is overlooked.

A Good Brush is worthy of good treatment; it therefore behoves the amateur who does not use his brushes frequently, to clean them thoroughly after use. Wash them out with soap and warm water. The cheap soap containing an excess of soda answers well. Damp the brush and rub it on the soap, rinse out, and repeat until perfectly clean. A final rinse in turpentine will leave the brush in good condition for use at any later occasion.

On no account allow linseed oil to dry in the brush, as it is almost impossible to remove after oxidisation takes place.

When brushes are used frequently, it is a good plan to store them in an old paint pot or a jam jar, keeping the bristles covered with water. If, however, the brush is one with glued-in bristles, it is advisable not to use water, as this sometimes results in loose hairs. The bristles must not be allowed to rest on the bottom of the receptacle, otherwise the brush will be ruined. Drill a hole through the handle and suspend it from a piece of wire pushed through the hole and supported by the sides of the container.

For further particulars on the subject of painting refer to the section on HOME DECORATING.

If the worker is proud of his handiwork he will take care not to spoil it by bad finishing.

In cases where the joints are not quite what they should be, it is possible to hide the imperfections by means of fillers and paint, but where the work has been well done it is well worth while to try to retain the beauty of the wood and the workmanship also. This can often be done by calling into use one or other of the numerous stains that can be obtained ready for use or can be easily made as required. If a suitable stain is chosen, any beautifully grained wood, such as some kinds of oak, retains its beauty, which is very often greatly enhanced.

Staining.—Wood, then, is stained to improve the appearance of the more expensive kinds, or an inferior wood such as pine, birch, etc., is stained to represent or imitate a good quality wood.

Creosote, when used for outside work, acts as a decorative stain as well as a preservative medium. It can be used for interior decoration, but it takes longer to dry than the usual stains meant for such work. It may be obtained in various tints in the form of proprietary products, under various trade names.

The introduction of aniline dyes has opened up a vast field in the matter of stains. Aniline is a coal-tar product obtained by distillation, soluble in alcohol, ether, etc., but only slightly so in water. By treating it with various reagents, a range of colours is obtained of every conceivable tint. The green obtained from aniline has taken the place of the old poisonous green once obtained from arsenic; and the old-fashioned dyes extracted from logwood, tumeric, walnut shells, and other members of the vegetable kingdom are now scarcely ever used.

Oak.—The amateur may like to try his hand at staining oak, to produce artificially what would otherwise be produced naturally by age. This may be done by giving the wood several coats of liquid ammonia—the stronger the ammonia used, the darker the colour will be.

In the trade, the oak wood is encased in an airtight chamber and fumed with ammonia—hence the term "fumed" oak.

Mahogany may be given a richer, darker colour by means of several applications of bichromate of potash solution.

Pine and Birch can be stained to represent the beautiful and durable appearance of walnut by frequent applications of stain made by dissolving an ounce of permanganate of potash in ½ pint of rain water. It can then be applied with a piece of flannel worked in the direction of the grain of the wood. After being left for about 10 hours to dry, it can be varnished if desired.

Stains may also be obtained ready mixed with varnish; they go by the name of varnish stains, and are useful for finishing floorboards, etc.

Any wood that is well oiled gets darker in time. If the amateur has oiled the wood of his planes, he will probably have noticed this action of linseed oil. This method of darkening wood may be used on more important work, and if well rubbed into the pores the oil produces a pleasing semi-polished finish.

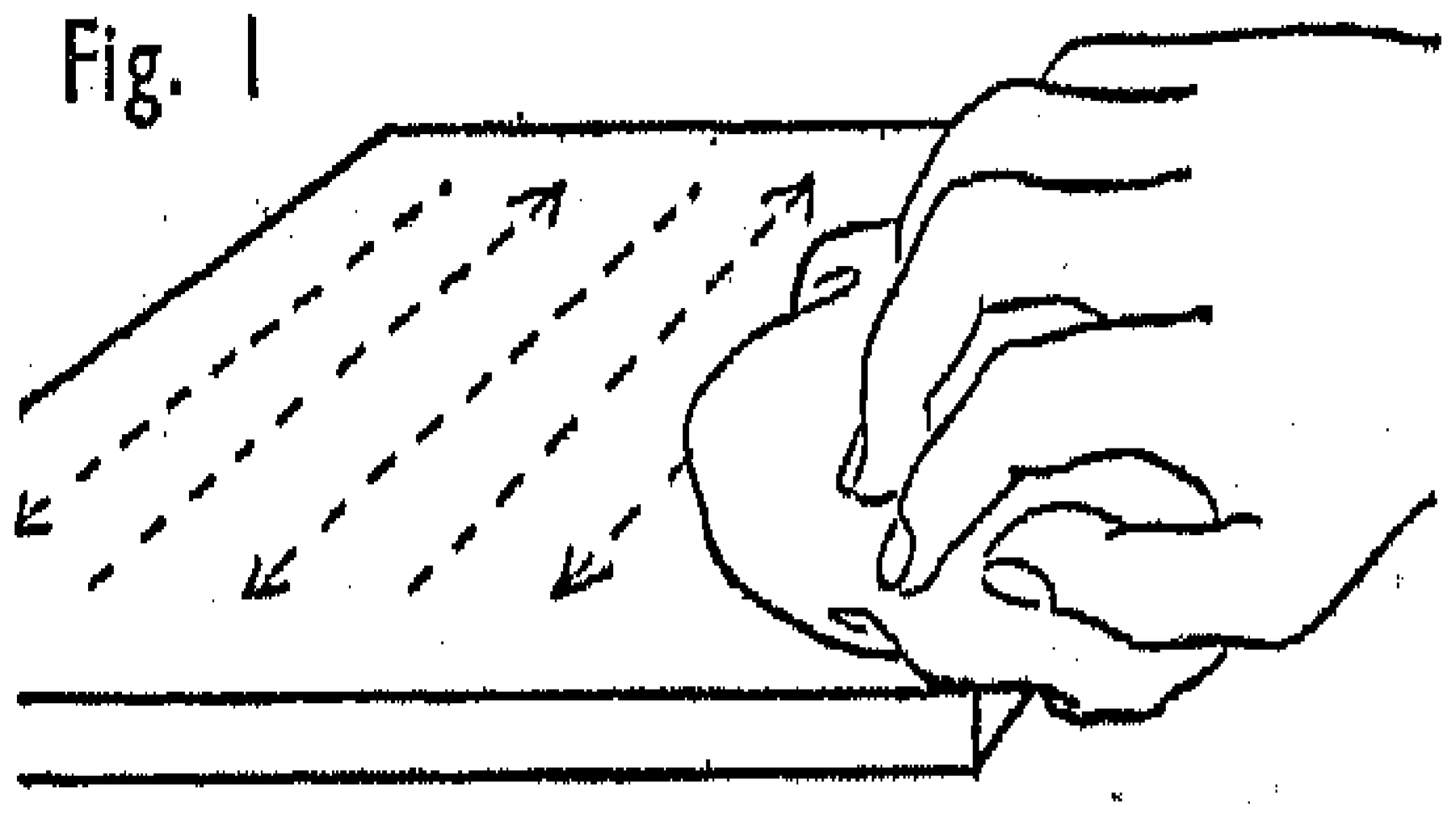
Polishing, or, as it is generally termed, french polishing, is chiefly resorted to for finishing good quality furniture, cabinets, etc. This finish gives the wood a fine smooth glossy surface, showing, in the majority of cases, the colour and natural beauty of the wood.

French polishing is also employed to enhance the impression produced in woods that have been stained to imitate a better class of wood.

This process of french polishing consists in applying a solution of shellac in methylated spirit evenly and smoothly over the surface to be finished. The polish is distributed over the wood, until the pores are completely filled, by means of a "rubber" consisting of a wad of cotton-wool wrapped in a small calico "bag." Polish is applied to the cotton-wool which, when squeezed through the calico by light pressure, adheres to the surface of the work and produces the delightfully smooth hard glazed surface so well known and generally admired by everybody.

The brief outline just given makes french polishing appear to be a much simpler process than it really is.

Fig. 1



A good deal of practice is necessary before reasonable proficiency is attained. There is no reason why you should not try your hand at it, but you will be well advised to practise on small panels of wood before attempting to french polish an important piece of work.

One of the chief points which leads to success in french polishing is that the process should always be carried out in a warm room free from dust. Good work cannot be done in a cold or even a damp atmosphere.

The Grain.—If the surface of wood is carefully examined, it will be noticed that the grain stands out more in some woods than in others. Some woods are much "coarser grained" than others; for instance, oak is much more so than walnut. This grain must be filled in because polish alone would not give the brilliant finish that is desired.

The first work of the polisher is to get the surface of the wood as smooth as he possibly can. This operation necessitates the use of the scraper and glass-paper. Two or three grades of glass-paper may be necessary, the last one used being a very fine one. In using glass-paper for finishing, do not, on any account, rub the paper across the grain, as such a procedure will almost certainly result in scratches which will show up more after polishing than before. Therefore, rub up and down the surface in the same direction as the grain.

Filling.—The next operation consists in filling the pores of the wood. The filling-in must be carefully done, as the filler forms the foundation for the polish. Any carelessness on the part of the worker in carrying out this important process invariably results in an unsatisfactory finish.

The amateur has the choice of several kinds of fillers. Plaster of Paris is the filler most commonly used, and it can be applied by one of several ways. One method is to make a pad by rolling up a piece of rag, moistening it with water, and then dipping it into the plaster of Paris, taking care to see that the latter is free from grit. Rub the filler well into the grain by working across it, as illustrated in Fig. 1, until the whole surface is well covered. Wipe off the surplus before it sets hard, but not so soon as to remove that which is intended to fill the pores. If the surplus is allowed to remain until it gets hard, great difficulty will be experienced in removing it with glass-paper. Having obtained a satisfactory result, allow it to dry thoroughly.

As the process of filling-in raises the grain of some woods, it may be necessary to give the surface another rub down with glass-paper. For this, use very fine glass-paper that has been used before, or, if this is not available, rub the sanded faces of two new pieces together before applying it to the work in hand.

Some workers prefer to use turpentine for filling purposes instead of water, in which case the grain is not affected in the same way.

If preferred, the plaster of Paris may be mixed into a paste with water and then applied to the work.

Another commonly used filler consists of plaster of Paris and melted tallow, the employment of which allows the polishing to be started at once; whereas fillers containing water must be allowed to dry before the work can be proceeded with.

Oiling the Surface is the next process whereby the surface previously made white by the filler is "killed," that is, completely obliterated. This is done with a rag moistened with linseed oil, and any surplus oil remaining is removed by rubbing the surface vigorously with a clean soft rag. Care should be taken not to leave any trace of oil, because the less there is, the more brilliant and solid the resulting surface will be. If too much oil is left on the work it may also eventually cause trouble to the finished surface, due to "sweating."

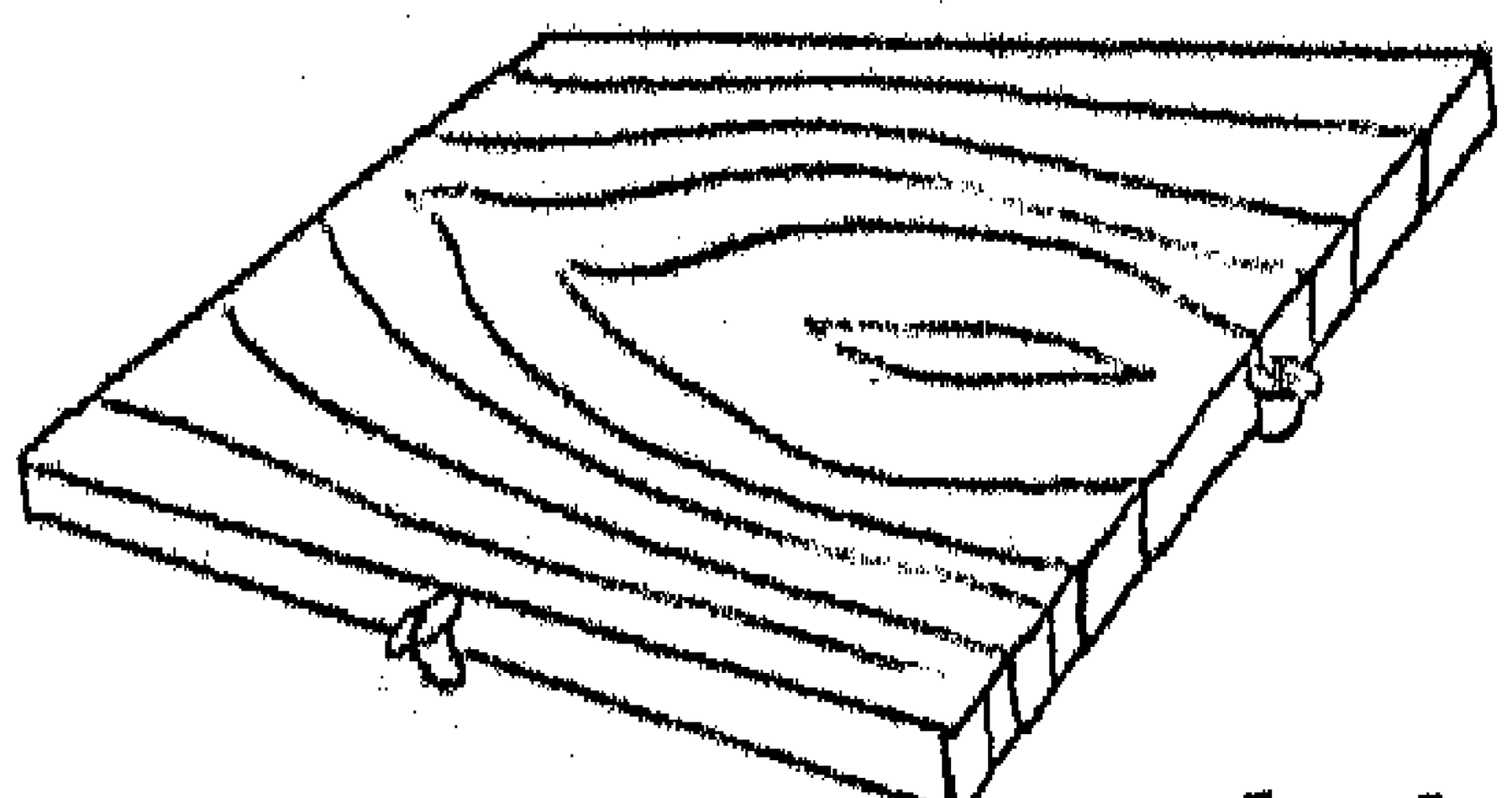


Fig. 2

If the wood is to be stained, the stain may be applied after filling-in. In some cases the stain is added to the polish itself.

Polishing Filled Wood.—Where plaster of Paris filling has been used, the surface may now have a preliminary or foundation coat of polish. If the work in hand is a small panel it is an advantage to fasten it down to a flat surface by means of screws in the manner shown in Fig. 2. Take a wad of cotton-wool and soak it full of polish. Fold it in a piece of used calico rag to form a rubber as shown in Fig. 3, and pass it over the surface to be polished, squeezing the polish out slowly as the rubber glides over the surface. Take care to cover the whole of the surface, especially the sides and corners. Do not rub hard or attempt to polish whilst laying on this foundation coat, because a good base of polish is required for working on later. When this operation is finished, place the work aside to allow the surface to dry thoroughly and harden.

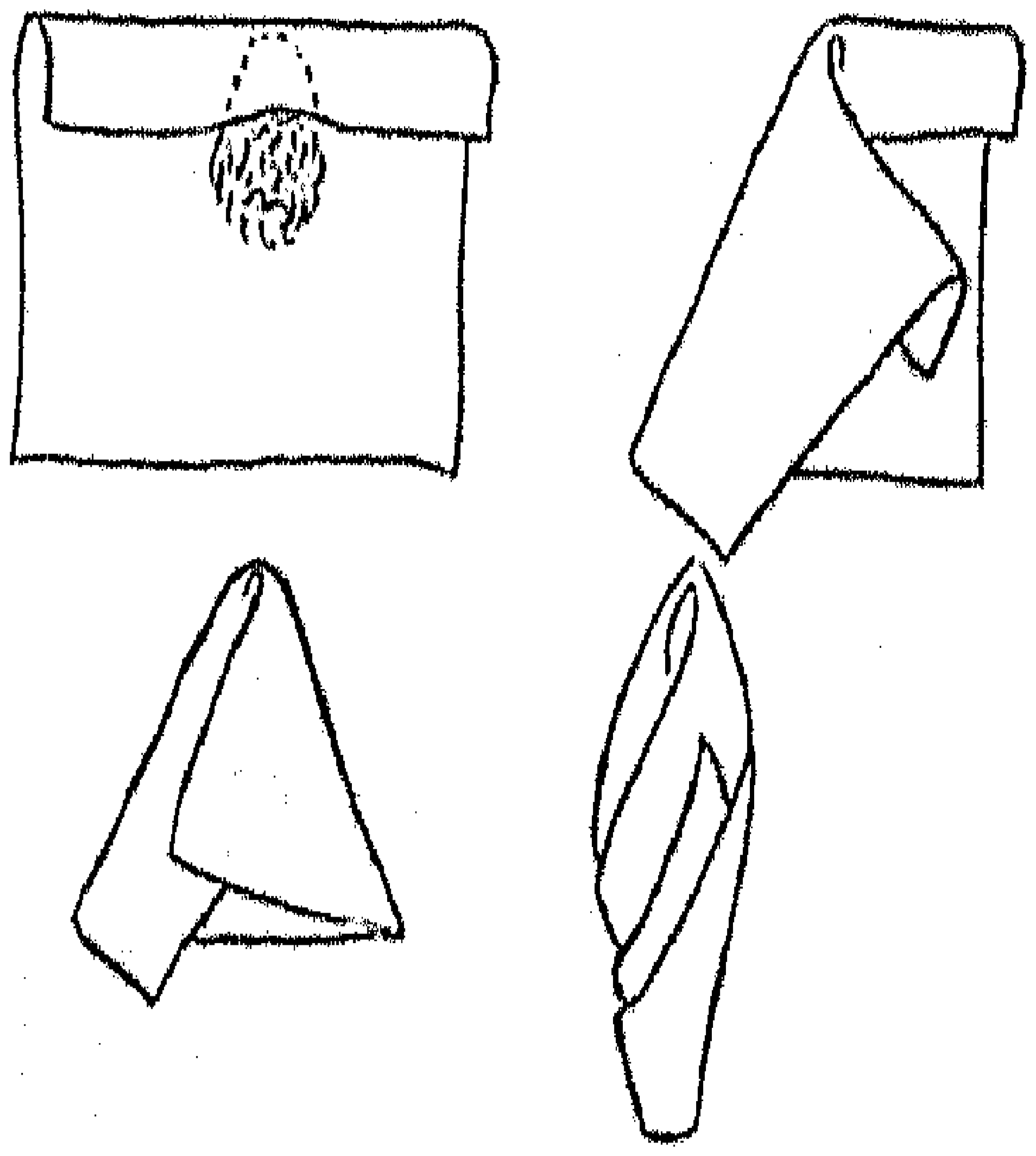
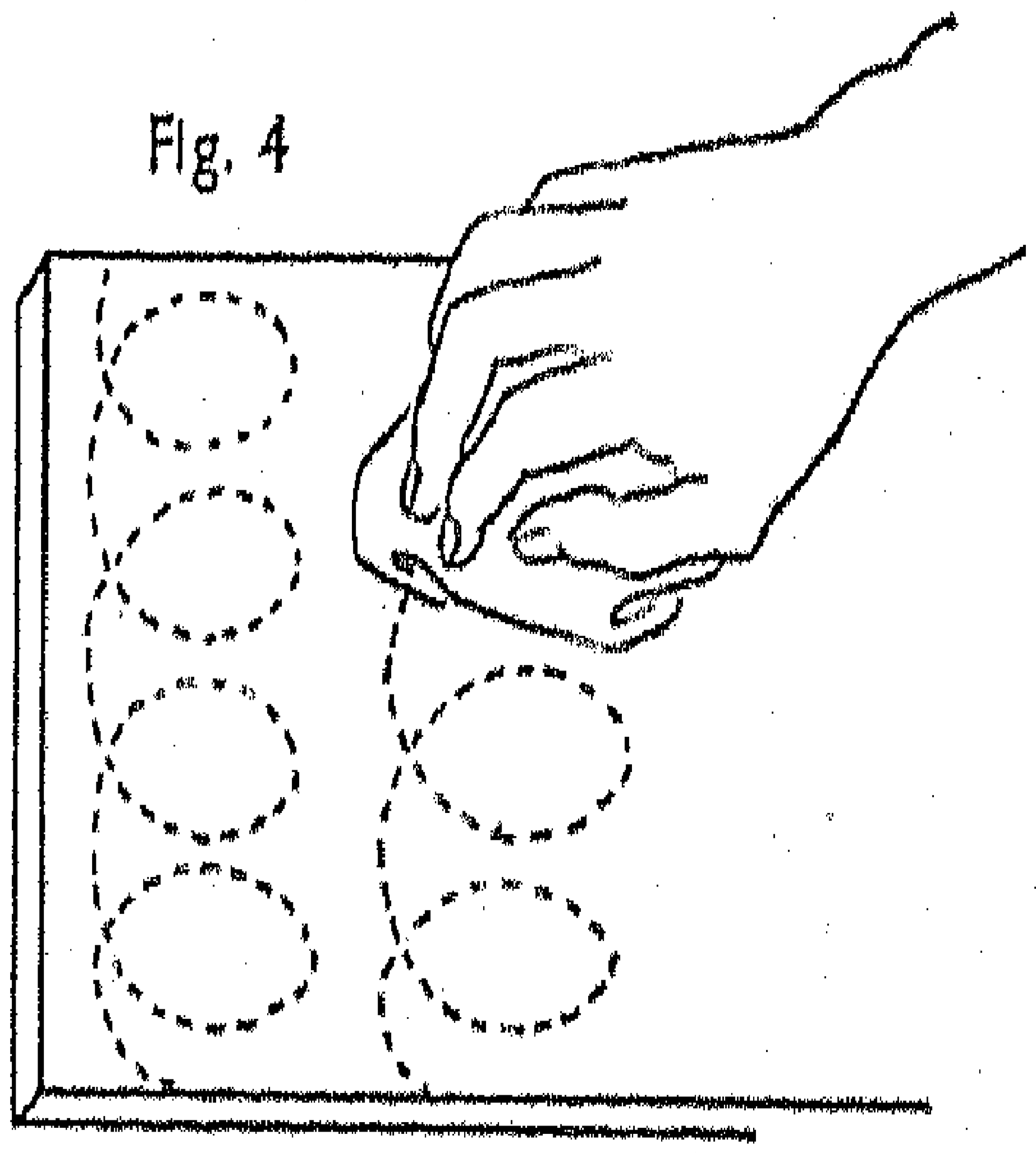


Fig. 3

As the rubber will get hard and therefore useless by the time it is next required, due to the evaporation of the methylated spirit, it is a good plan to soak it in polish and then store it in a small airtight tin or jar.

Fig. 4



When the work is thoroughly dry, go over the entire surface with fine sand-paper—No. 1 grade paper should answer the purpose well. If the foundation does not appear satisfactory after sand-papering, apply another coat of polish.

Bodying-in.—If all is correct, the actual polishing can be started. The rubber used for the first coat will do for this if it has been kept moist as suggested. Charge it with polish as before, but not so copiously, and fold the rag over the cotton-wool so that it is fully enclosed, and hold the loose ends in the hand.

Apply a spot or two of linseed oil (some prefer almond oil) to the face of the rubber. This acts as a lubricant which prevents the pad from sticking and dragging along the surface of the work. Failure to include this important item may possibly ruin the work. Do not use too much oil, otherwise it will subsequently cause trouble.

Method of Rubbing.—Apply the charged rubber to the surface and rub the pad in a circular motion over the face of the wood as indicated in Fig. 4, so that all parts are covered uniformly, taking care not to press too hard on the pad or you may possibly rub off the polish you have put on.

The rubber may need many applications of fresh polish until eventually a beautiful finish is seen following the course of the pad, but it may appear somewhat smeary.

Put the work aside to dry, which may take a day or two.

Subsequent examination will probably reveal that the polish has sunk somewhat, perhaps unevenly. Use the sand-paper lightly, and then give another bodying coat. Good work is often gone over three or four times in the manner described.

After these coats have been allowed to dry thoroughly and harden, give the work a good rub with a clean soft rag to remove any dust that has settled on the surface and also any oil that may have found its way through the coat.

The finishing coat is then given with the same rubber, charged with french polish and spirit in equal proportions. Be careful not to saturate the rubber; otherwise it will possibly destroy the hard surface that has been so carefully produced. If, on dabbing the pad on the back of the hand, it feels wet, squeeze some out and let the rubber dry off a little. It should feel only slightly damp.

Apply a spot of oil to the rubber, and then run it over the whole surface of the work, using horizontal strokes only. This application should be sufficient slightly to soften the surface and leave it ready for the final glaze, which is produced by the friction of this final rubbing. Careless work at this stage may undo a lot that has gone before, but the careful worker can finish off with a clean, hard brilliant surface at this stage.

Spiriting-off.—Should the surface appear to be a little bit smeary after this treatment, it should be run over in parallel sweeps along the full length of the work with a rubber charged with spirit only.

Such a rubber is sometimes called a "ghost" and the process is called "spiriting-off."

The pad is prepared as before with cotton-wool covered with a piece of calico, but the wool receives only a slight charge of spirit, and must on no account be wet. To verify the condition of the pad it is a good plan to test it on the cheek.

Sweating.—The rubber may then be applied to the work to enable it to take off any smear or oil that has exuded, causing what is termed "sweating."

It is claimed that almond oil does not cause sweating like linseed oil. It should be the worker's aim to use as little as possible and to clear away any excess

during the latter stage of obtaining the final lustre. Some woods are naturally oily and this should be taken into account.

Furniture cream and polish-revivers are used to keep a polished surface in good condition.

An excellent reviver for dull surfaces can be made by mixing together 4 oz. of spirits of wine, 2 oz. of vinegar and 1 oz. of linseed oil. Rub well on and polish with a soft cloth.

A useful polish for stained softwood is made up as follows: Melt some beeswax, and add a small quantity of turps and linseed oil. Stir the mixture and then add a smaller quantity of kerosene. When cool it should form a thick paste, but if not, add a little more of each ingredient. The more often this mixture is applied and polished off the work, the finer the result will be.

A harder finish is obtained by using carnuba wax instead of beeswax. Allow it to soak in before polishing-off with a soft cloth.

PLYWOOD

The advantages of using plywood in preference to ordinary wood are manifold. The most important of these are its freedom from shrinkage; its enormous strength; the large widths in which it can be obtained, and its adaptability to certain shapes and forms. Another great point in its favour is that it can be obtained with expensive woods such as oak, walnut, mahogany, etc., on one face cemented to a cheaper wood on the lower plys. In this way it is possible to get the beautiful effects generally associated with high-priced woods at a very much reduced cost.

Composition.—The freedom from shrinkage and the strength is obtained by the manner in which the material is built up. The first layer has its grain running in one direction and the next has the fibres at right-angles to the former, and this is carried on alternatively throughout the thickness.

In some makes of plywood the inner layers are slightly thicker than the outer ones to ensure a balance of strength in both directions, and the several layers are cemented together with a special cement which is claimed to be unaffected by damp.

A standard-sized sheet of plywood faced with walnut, mahogany, oak, etc., measures 60 in. by 48 in., while those faced with common woods such as birch and alder are to be obtained in sheets measuring 48 in. by 36 in., and 60 in. by 48 in.

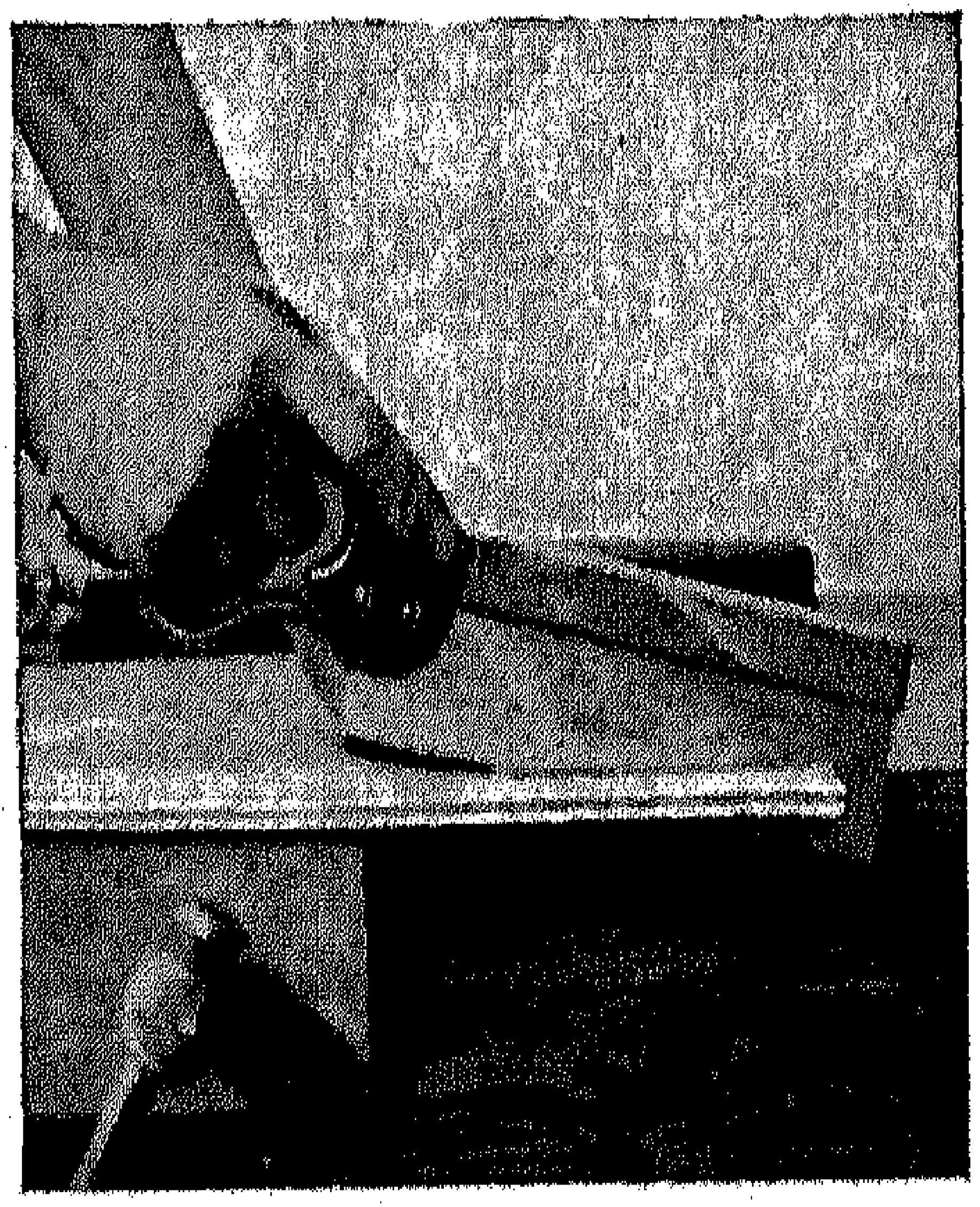


Fig. 1

There is no need to purchase a large panel where only a small quantity is required, because panels as small as 6 in. by 6 in. and other convenient sizes suitable for the home carpenter, can now be obtained from any of the numerous shops, to be found in nearly every town, which cater for amateur woodworkers' requirements. It can also be purchased at most hardwood stores.

The thickness of plywood varies from $\frac{1}{32}$ in. to $\frac{3}{4}$ in., having from three plys to as many as nine.

Fig. 2

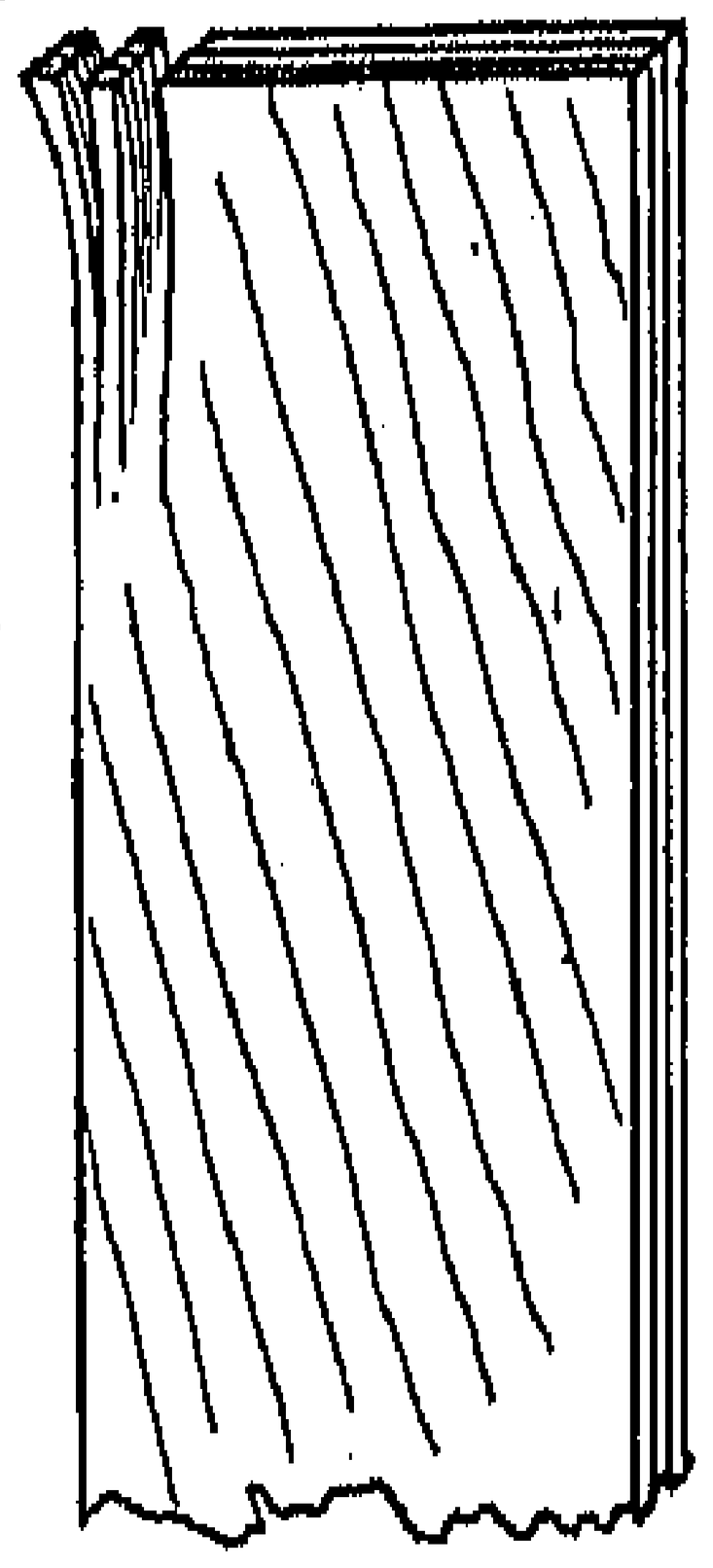
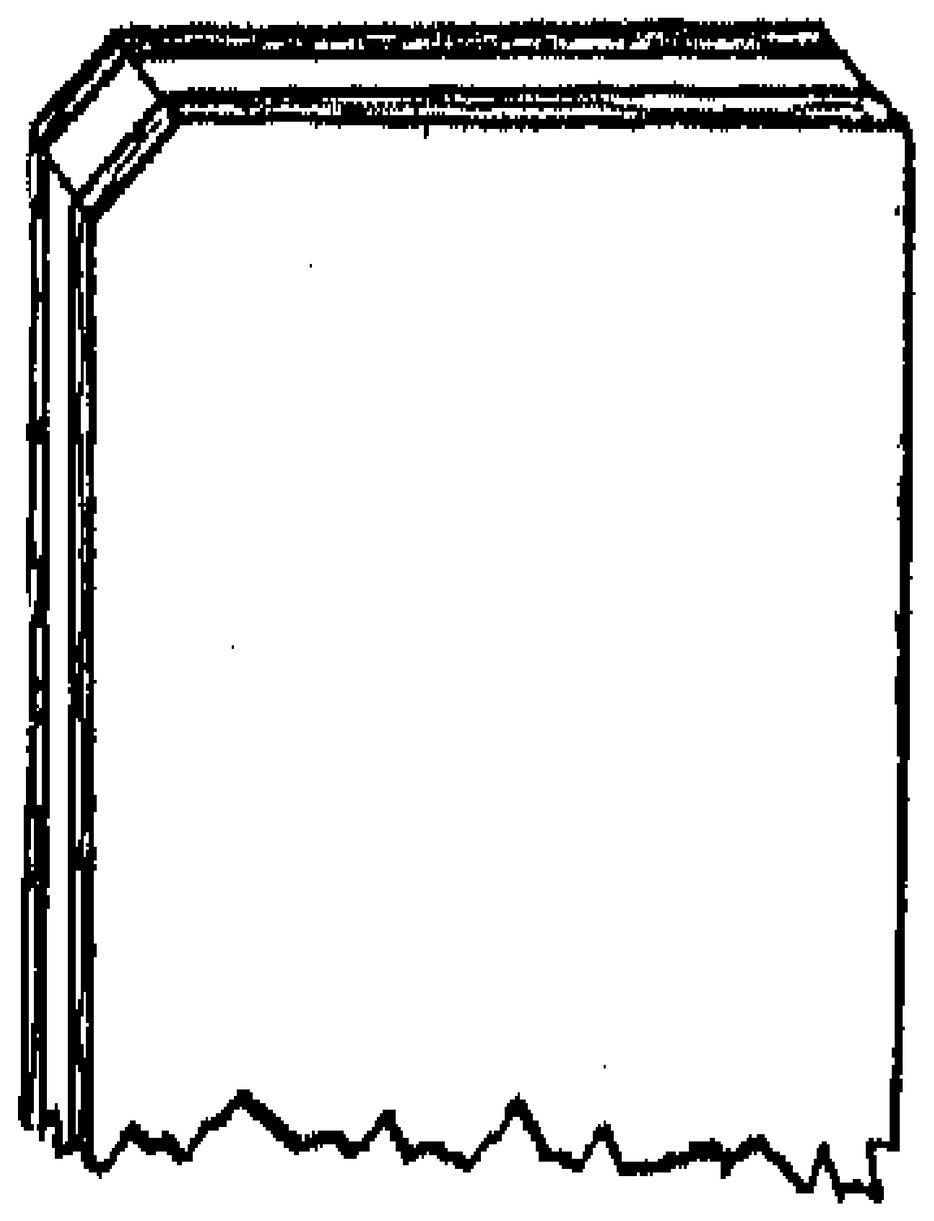


Fig. 3



Varieties of Plywood.—Like ordinary wood, there are various qualities, the commonest of which is only suitable for packing-cases—but the better grades have an excellent surface. In the commoner varieties of plywood, that is, those faced with birch and alder, the best quality is good on one face only, while the third quality has slight defects on both faces.

The thinnest plywood ($\frac{1}{32}$ in.), which is not much thicker than average cardboard, can be cut quite easily with a pair of sharp scissors, or a chisel held at an angle and drawn across it, but for cutting thicker material a fine-toothed saw should be employed. Never attempt to cut plywood with a coarse-toothed saw, otherwise the lower layer will split away.

Fig. 1 shows an illustration of a piece of plywood being cut with a tenon-saw. In cutting, the material should be well supported on a flat surface, and the saw held at a small angle to the surface in the manner shown clearly in the drawing.

Care must be taken when truing up the edges of plywood because all edges have one or more layers exposing the end grain which are likely to split out as in Fig. 2 if planed right across. Use a very sharp, finely-set plane, and plane from each end to the centre, as in planing the end grain of ordinary wood. Another method to prevent damage to the edges is first to remove the corner with a sharp chisel as shown in Fig. 3. This method, however, can only be adopted where the corners do not show, as for instance when it is sunk into grooved wood.

A fretsaw is an ideal tool for cutting small and comparatively thin pieces of plywood to shape, as the fine teeth produce a clean edge and are not likely to damage the outside laminations. For convenience in cutting it is an advantage to use a proper cutting-board having a V-shaped aperture for supporting the work, as explained in the article dealing with FRETWORK.

Owing to its exceptional strength, thin plywood is extensively used for making "frets" or ornamental openings in the fronts of loud-speaker cabinets. To make such a fret, all that is necessary is to mark out first of all the design on the face of the material, using a pencil for the purpose, and then remove the internal waste with a fretsaw.

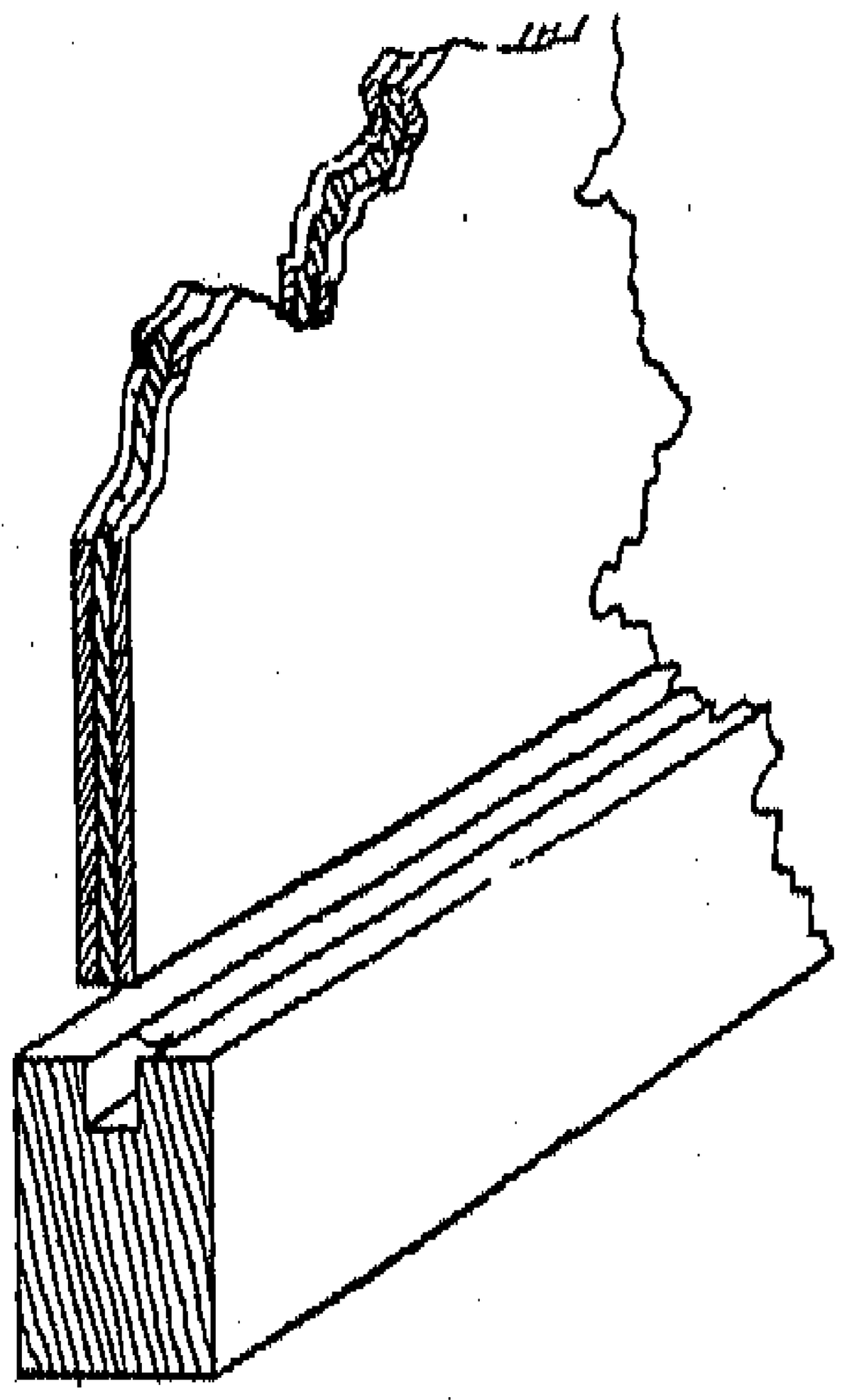


Fig. 4

Where a number of similar shaped pieces are required, a great deal of time will be saved and accuracy assured if a cardboard template of the exact shape is made and then used as a guide for marking purposes. This method simplifies marking-out and is very often the means of saving a considerable amount of material.

Plywood is exceedingly useful for making light furniture such as cabinets, chests of drawers, and other useful and ornamental articles.

There are several ways of using plywood for this purpose. In one method—perhaps the best—the framing is grooved to take the correct thickness of the panel (as shown in Fig. 4), where the material has to be in place before the framework is fastened together. Fig. 5 shows the framing with a rebate cut sufficiently wide to allow for the thickness of the panel and a narrow moulding. In this case, the frame is put together first, the panel inserted into the recess, and kept in place by either gluing or pinning a moulding to the inner edge of the frame. Fig. 6 illustrates another simple way of fitting plywood panels. The inner edges of the frame are left square, and a narrow moulding is first fixed near the back edge to form a rebate. The panel is then inserted, and kept in position by the front moulding.

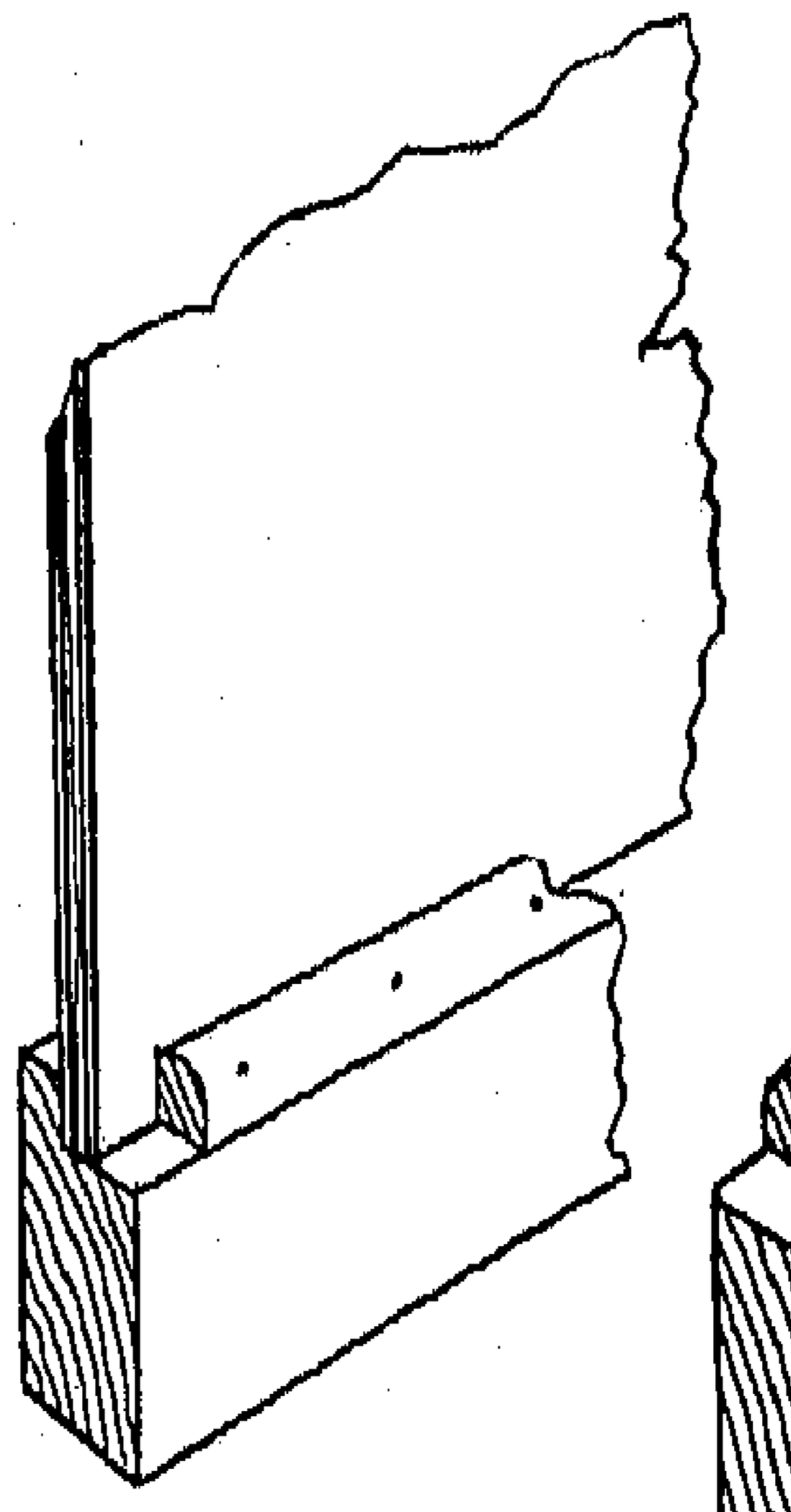


Fig. 5

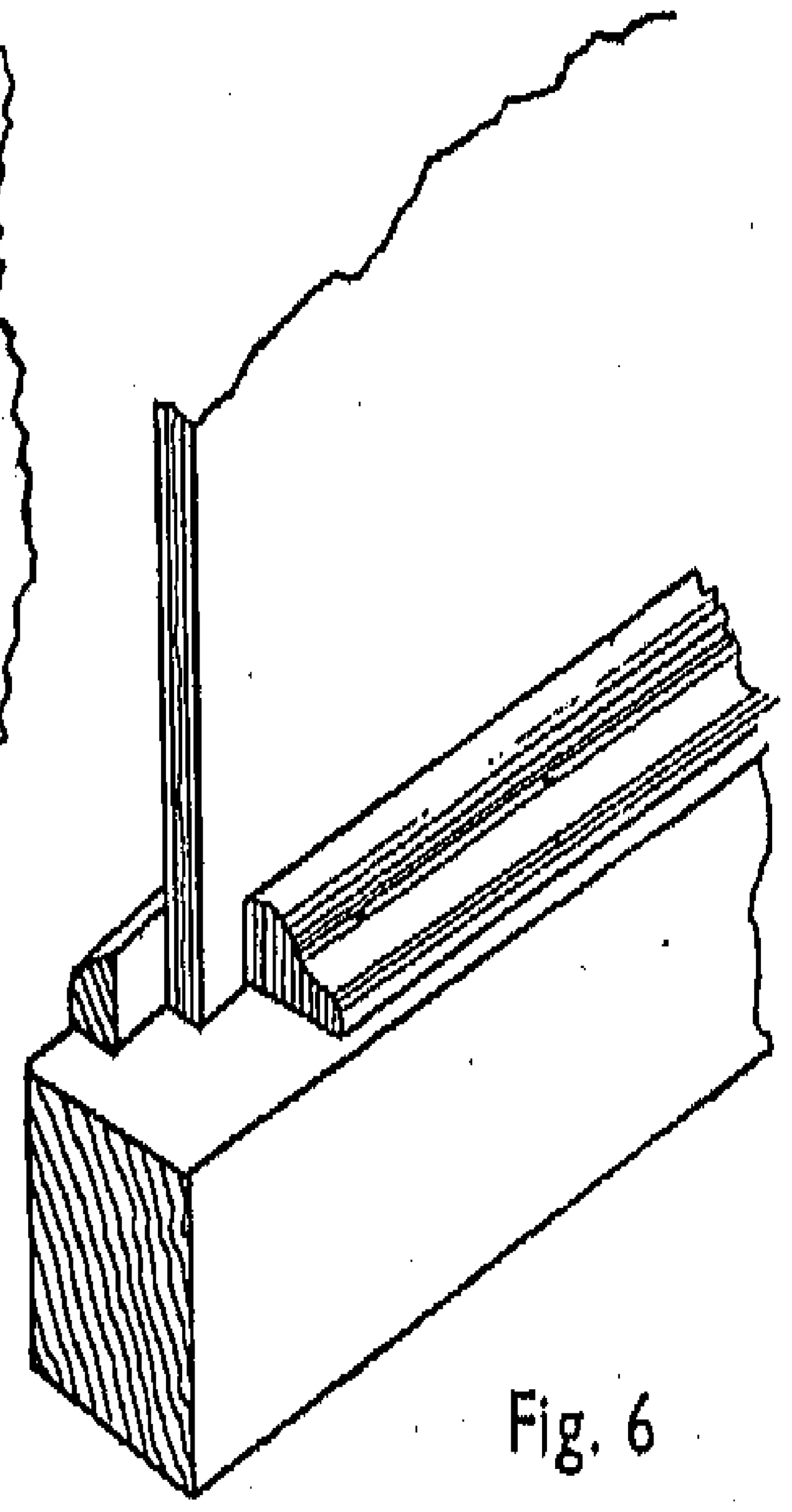


Fig. 6

In some work the panels are left loose in the recesses, but in some cases it is advisable to fix them in with glue.

Grooved Framing.—Suitable grooved material of various sections and shapes for making the framework for thin plywood panels can now be obtained from most hardwood shops. The grooves are usually made to take panels $\frac{3}{16}$ in. in thickness, and are provided with recesses on one or more faces.

This useful material is of inestimable value to the home carpenter as it eliminates the somewhat tedious tasks of ploughing grooves and making rebates, and enables a first-class job to be accomplished with a minimum amount of labour by the use of a few ordinary tools.

On account of the non-shrinking and non-twisting characteristics of plywood, it is possible to make serviceable doors for cabinets, etc., without any orthodox framework, by simply gluing or pinning a plain or an ornamental moulding round the front edges of the panel, as illustrated in Fig. 7. Mitred joints are used, of course, at each corner of the moulding.

This form of door, however, is not so good as a door having a proper grooved frame surrounding the panel, the joints of which can be either a dowelled joint, or a stub tenon cut in the top and bottom rails to fit the grooves of the stiles.

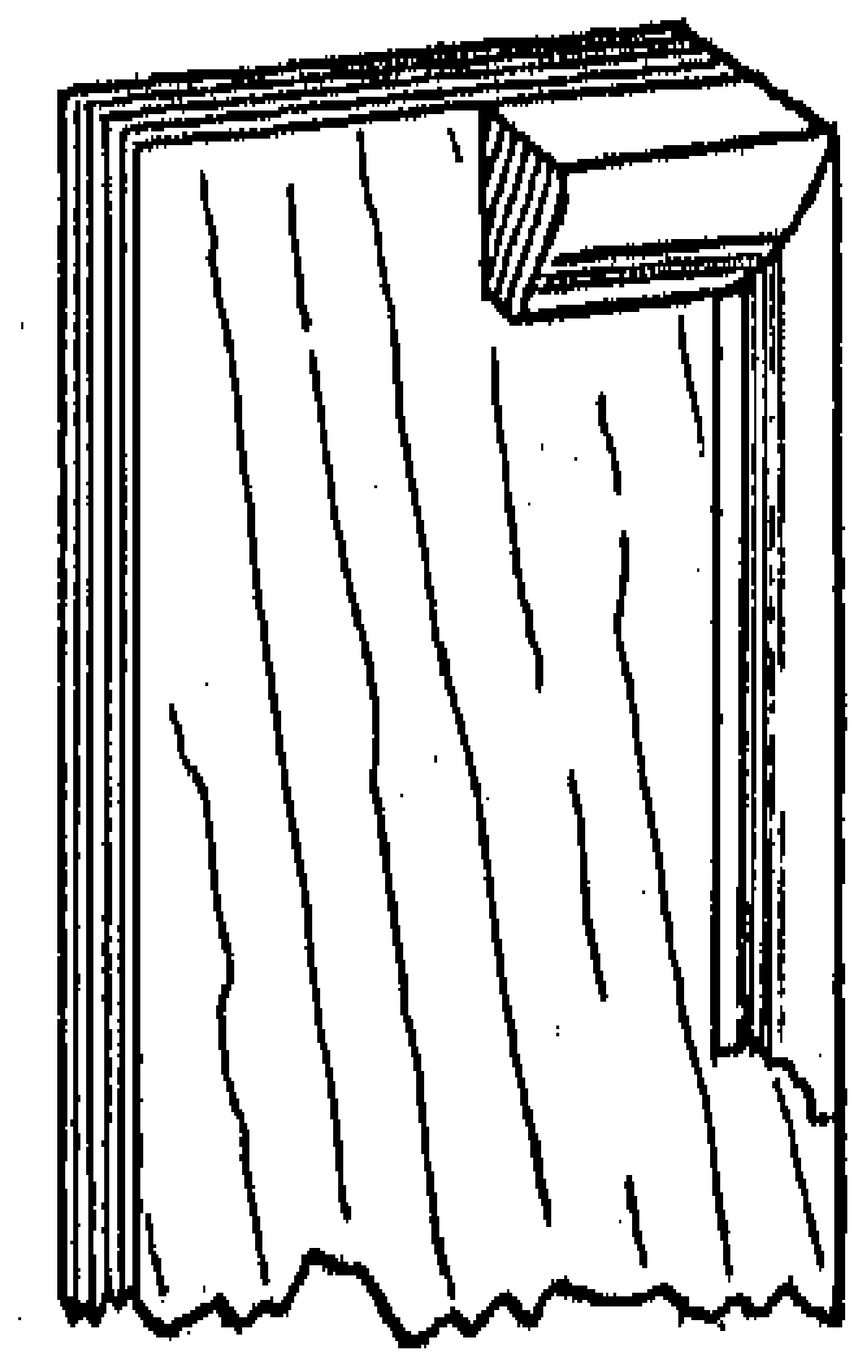


Fig. 7

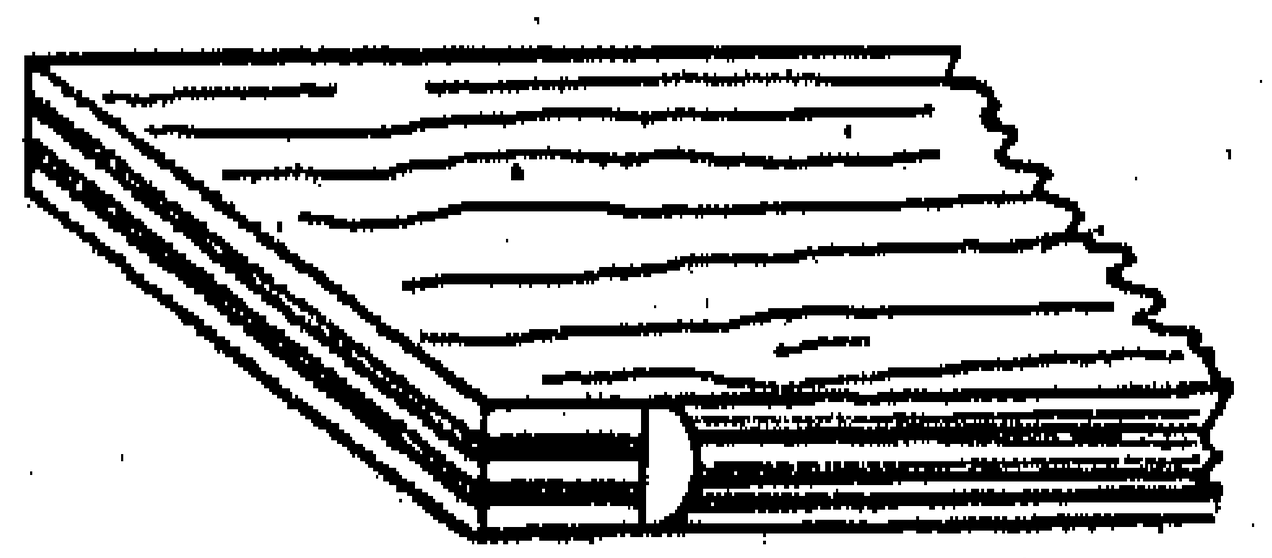


Fig. 8

Some workers object to the use of plywood on certain work because the laminated edges have rather a rough and unfinished appearance. This difficulty, however, is easily overcome by fixing a small edge moulding over them, as indicated in Fig. 8.

When fixing such mouldings great care must be taken to drive the pins into the centre layer of the plywood, otherwise damage may be done to the outside faces by splitting them apart. Another important point is to use always long thin panel pins driven in at an angle to form "dovetails," because this method makes a stronger joint than pins driven in straight.

Panelling.—Plywood offers an easy means of panelling a room. The advantages gained by the use of this artistic material for decorative purposes are too well known to be mentioned. Only best quality plywood should be used, whether it be faced with oak, mahogany or any of the commoner kinds of wood.

If the walls to be panelled are perfectly dry and even, the plywood may be nailed directly to the surfaces, but should there be the slightest suspicion of dampness the panels must be mounted on battens to allow the air to circulate between the walls and the covering material.

Where the panels are fastened to the walls without any intervening battens, the first thing to do is to mark the walls to suit the spacing of the panels, and then cut the plywood to size. It is a wise plan to leave a small gap of about ⅛ in. between each panel to allow nails driven in the centres of the covering strips to enter the plaster. The panels should be fastened with 1½-in. oval brads driven in slantwise to obtain a good grip, care being taken to see that the nail heads are eventually hidden by the covering strips. Before fixing the covering strips, however, the whole of the panelling, as well as the strips, should be stained or otherwise finished to the desired shade, and then wax polished. The strips can be touched up after erection.

Should fixing battens be necessary, the walls are marked as previously mentioned, and the battens securely fixed to the walls. The wood used for this purpose need not exceed 1¾ in. in width and ¼ in. in thickness. The panelling is then fixed in the same manner as already explained.

A few years ago the writer wished to panel a room in oak-faced plywood. At the time, great difficulty was experienced in trying to obtain the chosen material, so a plywood having a face of Siberian ash was offered. This material had a beautiful figured surface closely resembling figured oak, but the size of each panel was 50 in. by 25 in., which meant a lot of cutting to waste.

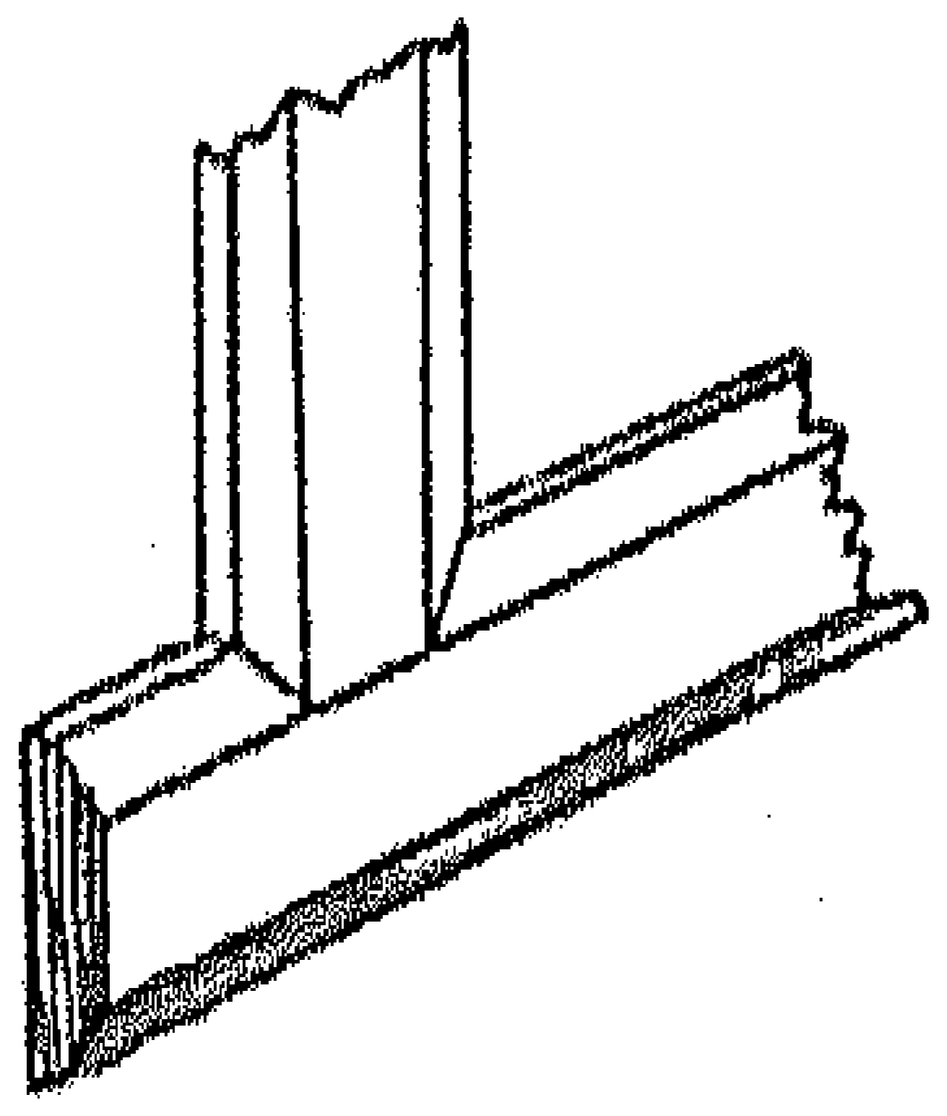


Fig. 9

To overcome the difficulty, the panels adjoining the skirting-board were laid and fastened longitudinally, while the panels above them were fixed in a vertical position. This left a gap between the upper and lower panels which was eventually covered by wide covering strips forming a useful chair rail. The panel joints were covered with bevel-edged strips of wood, the ends of which were cut to fit over the bevelled edge of the piece it had to join, as shown in Fig. 9. This was found the best and simplest method of solving a seemingly difficult problem.

FRETWORK

THE art of fretcutting is both fascinating and instructive and the necessary skill can be acquired with very little practice. Indeed, it is quite possible to become proficient in the course of a few days.

Such objects as cabinets, photo-frames, glove-boxes, and a hundred-and-one useful and beautiful articles can be made with the aid of a very limited number of inexpensive tools. The space required for carrying on the work need be no more than the end of a kitchen table to serve as a work-bench.

To commence work, all one actually needs is a saw-frame, saw-blades, drill-stock and bits, cutting-board, a supply of fretwood, and a pattern or design to work to, unless, of course, one goes in for the more expensive fretwork machine.

The Hand-frame.—This is the principal tool used for fretcutting, and is shown in Fig. 1. It consists of a light steel frame into which a fine saw-blade is placed, the clamping screws fitted at the top and bottom providing a means of gripping the blade. A handle is fixed to the bottom of the frame for working the saw up and down.

In a good type of frame, costing about 5/-, an adjusting device in the shape of either a lever or a special clamp having a screw thread and a wing nut is provided at the top for altering the tension of the blade, while a screwed arrangement in the handle allows further adjustment, that shortens and tightens the distance between the clamps.

These are very useful features, as they allow saw-blades, which one may be unfortunate enough to break, to be used again—provided, of course, that the break does not occur in the middle of the blade, and thus render it too short.

The sizes of frames, which refers to the distance between the back of the tool and the saw, vary from 12 to 18 in. The size recommended depends upon the size of the design likely to be cut, but when deciding upon the size required, the fact that the corners of the material have to be negotiated must not be overlooked.

Generally speaking, a 14-in. hand-frame is a very convenient size to get, and the type provided with the refinements mentioned is to be preferred; it is well worth the small additional outlay. Such a frame will answer well for most amateur purposes and is not too awkward to handle.

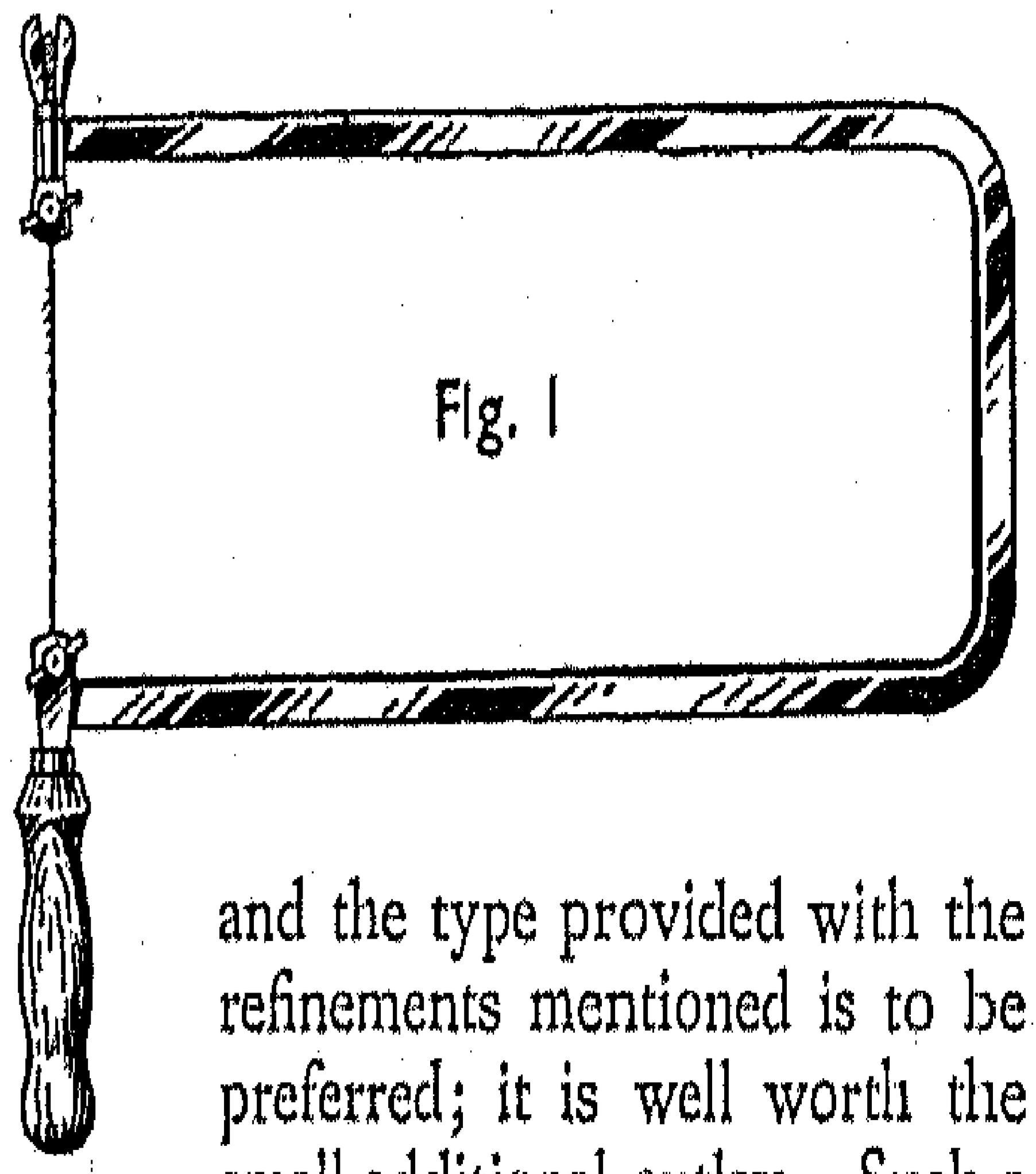


Fig. 1

Saw-blades.—The secret of success in fretwork depends in no small degree upon the tiny saw-blade, so a hint or two as to suitable blades will not be out of place.

A good blade for rapid and clean cutting should have regular, sharp, hook-shaped teeth, spaced equally and not too close together. It should also be tempered to the correct degree.

To fulfil these conditions extreme care is necessary during the manufacturing process, and it is therefore obvious that an article of good quality will cost more than one that is inferior. Therefore, pay a reasonable price for your saw-blades.

One of the greatest mistakes made by many amateurs is to purchase cheap saw-blades, usually of Continental origin, which have none of the qualities referred to above.

The teeth, in the majority of cases, are irregular, blunt and without "set," and so close together that the blade simply gets choked with sawdust, thus rendering it quite unsuitable for the purpose for which it is intended.

A dozen good blades of British manufacture, costing about 4d. or 5d., will outlast a gross of the cheap variety, and will save you the annoyance and the utter waste of time occasioned by the continual stopping of work in order to replace a broken blade.

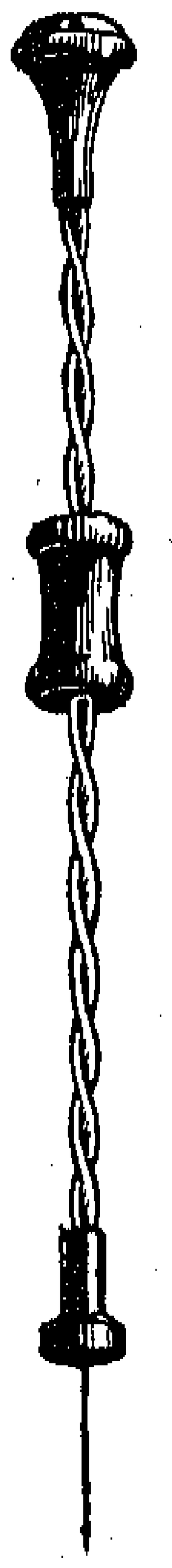


Fig. 2

Blades may be obtained in about a dozen different thicknesses or gauges to suit all varieties of work. A No. 00 is the finest and is only suitable for cutting wood up to $\frac{1}{16}$ in. in thickness. A No. 10 blade, however, is capable of sawing material ½ in. thick. For cutting wood over ½ in. in thickness a special blade called a toymaker's fretsaw is employed. Specially hardened and tempered steel fretsaw-blades can also be obtained for cutting brass, copper, and other soft metals, etc.

For general purposes you will find that a medium blade, either a No. 5 or 6, will give good results.

Archimedean Drill-stock and Bits.—An Archimedean drill-stock for holding thin diamond-pointed bits is the correct tool to use for drilling holes in fretwood. Such a drill is shown in Fig. 2.

Drill-stocks range in price from 6d. to about 2/6. A good type to have is one fitted with weights at the bottom and a device which allows the drill to rotate in a clockwise direction only. The weights allow a smoother and better cutting action, and if kept revolving permit the drill to be easily withdrawn from the material.

Cutting-table.—In order to do fretwork comfortably you should provide yourself with a suitable table or board.

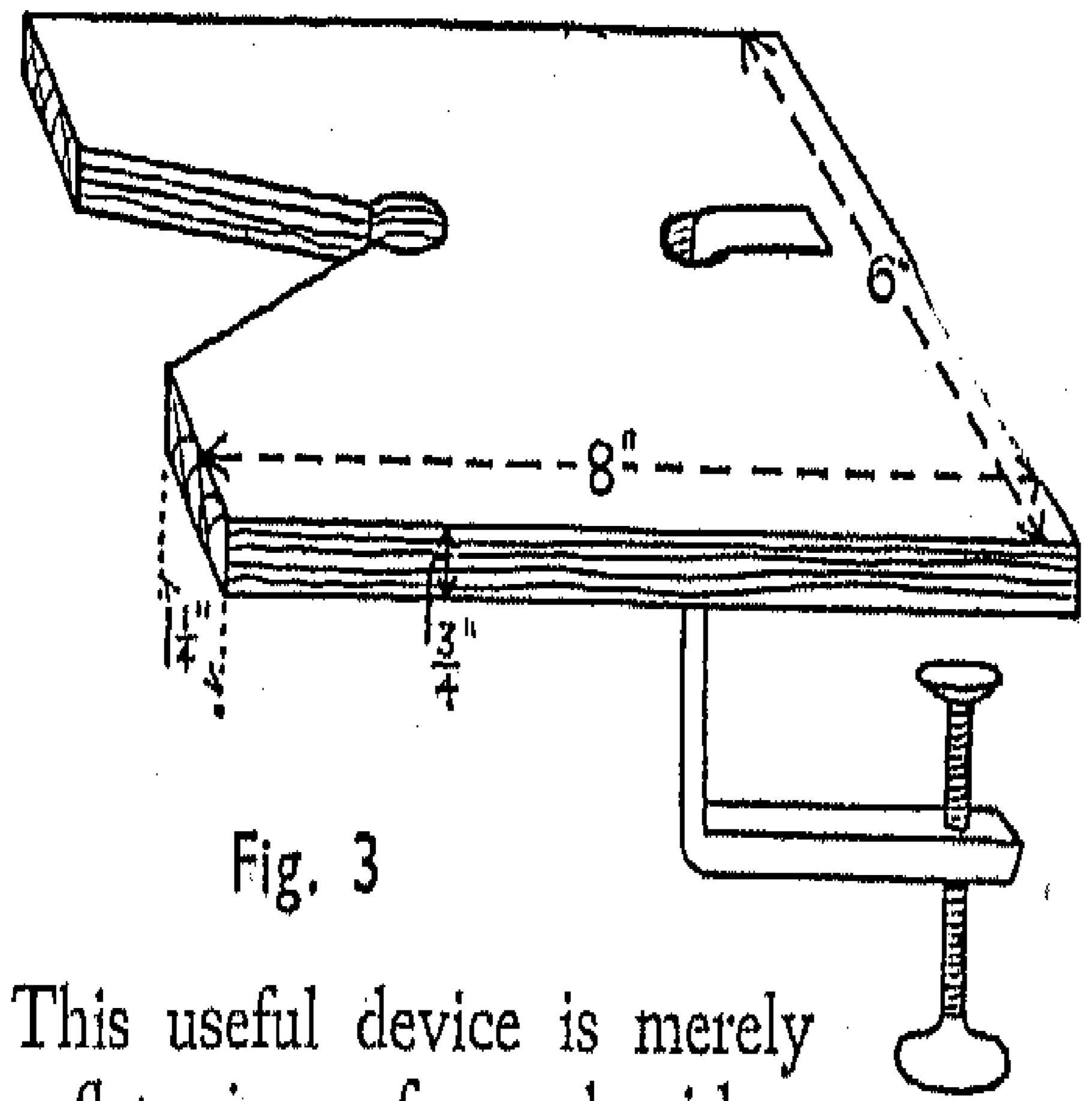


Fig. 3

This useful device is merely a flat piece of wood with a V-shaped slot cut in one end and a clamp for fixing purposes at the other, as shown in Fig. 3.

By clamping the board to the edge of an ordinary table a small projecting platform is formed which supports the work and prevents you knocking your knuckles against the table when operating the saw.

Another useful feature is that the board, being raised above the surface of the table, allows the material to be held tightly and swivelled round when required.

The cutting-table is one of those simple yet necessary articles which you can make for yourself, but if you prefer to buy one, you should see that it is made of wood and not metal. The latter kind is likely to injure the saw-blade should the teeth of the saw come into accidental contact with the edge of the platform.

To make a cutting-board, get a piece of perfectly flat planed board 8 in. in length, 6 in. wide and ¾ in. in thickness, and a small metal cramp costing only a few pence. Draw a pencil line parallel to a long edge in the centre of the face of the wood, and mark on this line the positions for the holes. The centre of the front hole is 3¾ in. from the front edge, and that for the cramp is 2½ in. from the back edge. Mark out the slanting lines to form the V-shaped recess to the dimensions shown in Fig. 3. Cut or bore the two holes, which should be ¾ in. diameter, and remove the waste from the recess. Cut a neat channel from the back hole to the back edge sufficiently wide and deep to allow the top of the cramp to lie flush with the top surface of the board.

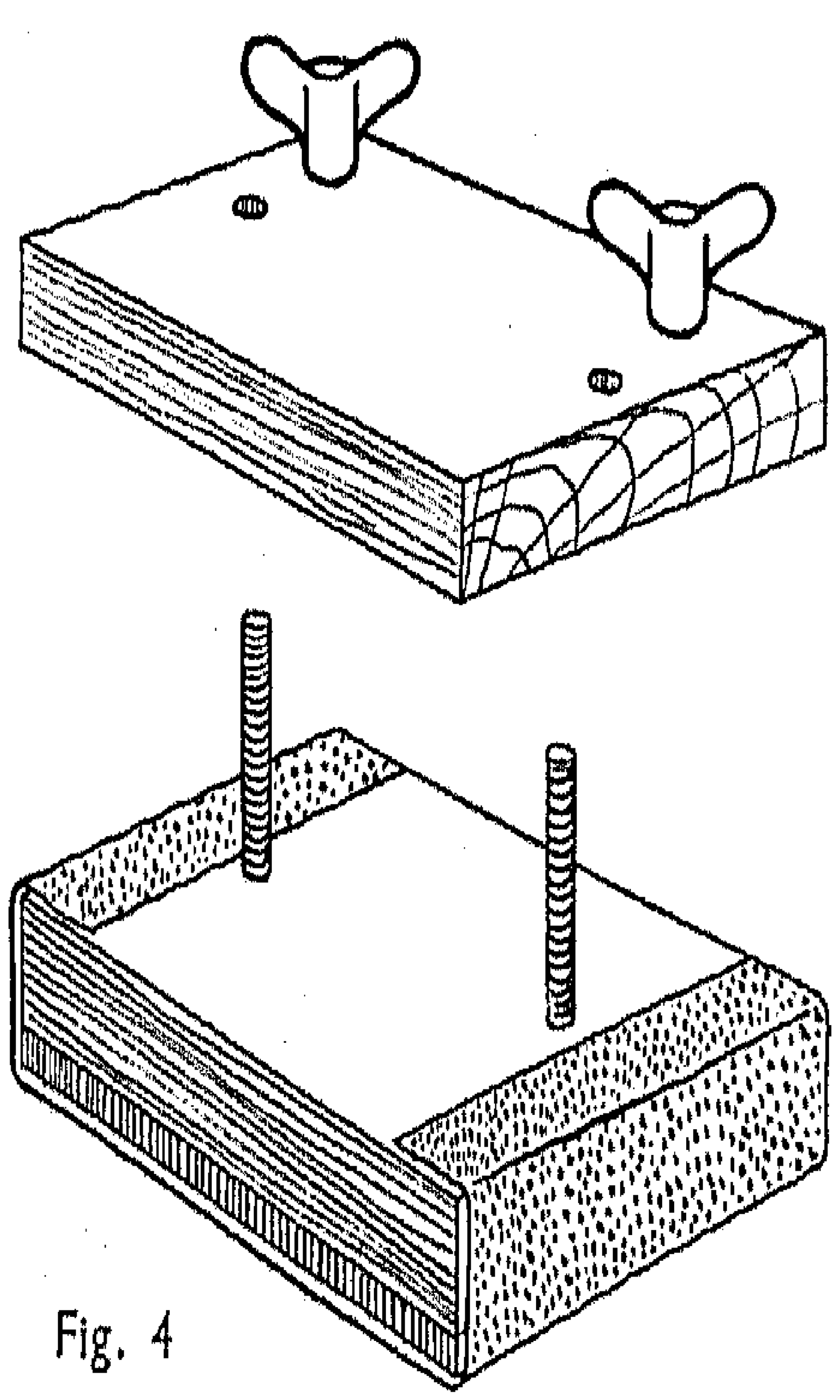


Fig. 4

An improvement on this board would be to use two cramps at the back.

If the board having a single cramp is inclined to twist round when in use, the difficulty can be surmounted by fastening a narrow strip of wood across the underside to coincide with the edge of the table or bench.

Glass-paper Block.—A glass-paper block is used for smoothing down and finishing off the work when completed.

Such a block in a simple form is shown in Fig. 4. It consists of two pieces of flat wood which form the top and bottom members respectively. A strip of glass-paper covers the bottom surface of the lower member and the paper is cut long enough to fold over the two ends and partially over the top. The top piece is then screwed down tightly to the lower portion and serves to hold the paper in position. This accessory can either be bought ready-made or constructed at home. Suitable glass-paper strips for refilling the blocks are easily obtainable.

Fretwork Designs.—The requirements of the fretworker in the matter of designs are amply catered for. Excellent pattern sheets costing only a few pence can be obtained from dealers in fretwork material.

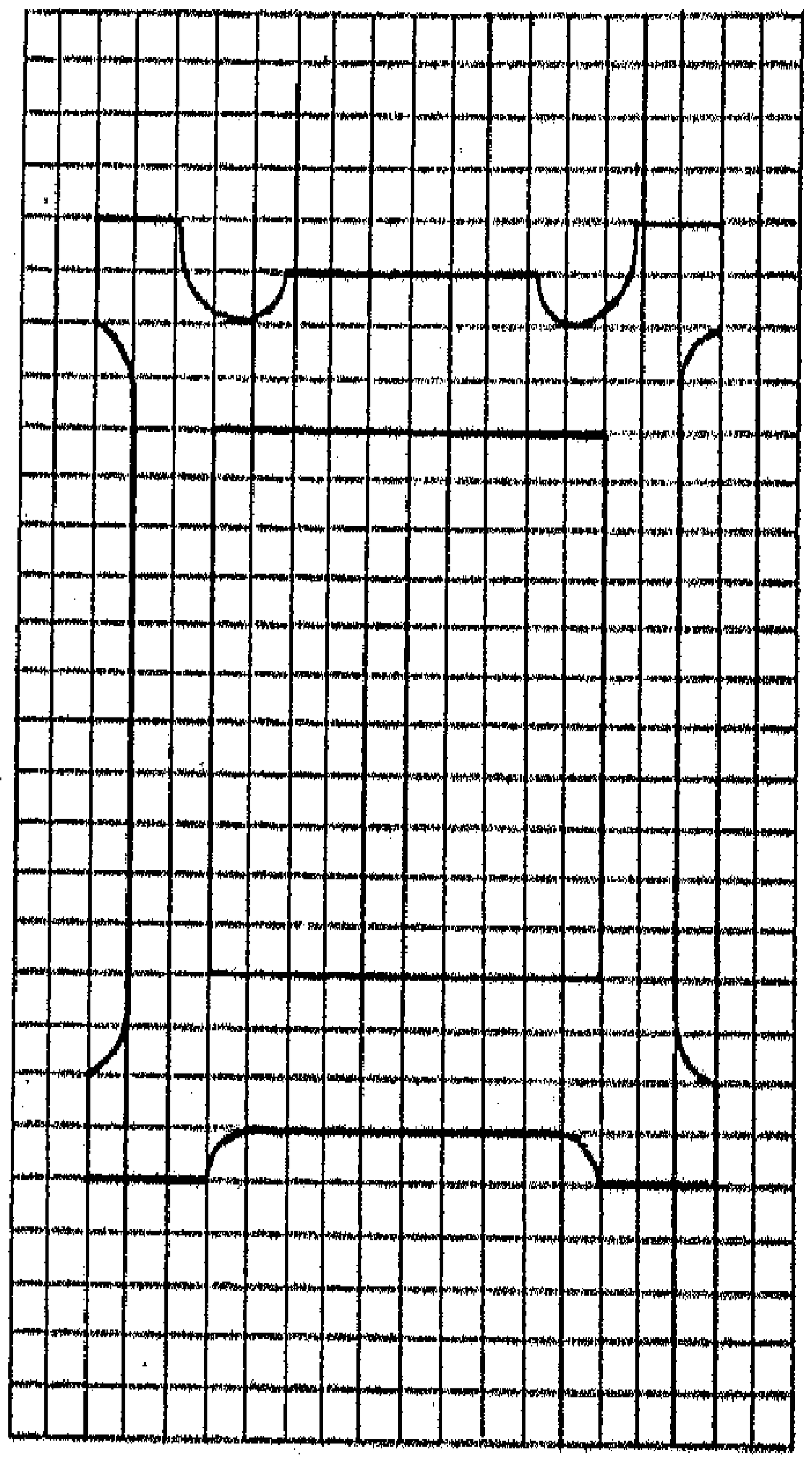


Fig. 5

The range of designs covers practically the whole of the smaller articles one sees in and about the house, from clocks to stationery cabinets, and umbrella stands to overmantels, while designs of models, toys, and the like are also readily obtainable.

It is possible that you may want to make an article of your own design, in which case you must first of all make a drawing. The pattern can then be either stuck down to the face of the wood in the ordinary way or the outline can be transferred by means of a piece of carbon paper as used in typewriting, provided that the material is sufficiently light in colour to allow the outline to be easily seen. The latter method is resorted to when the design is required for further use.

When making one's own design it is an excellent plan to use thin square-lined paper, as the lines are a useful guide for drawing curves, etc. accurately. Such paper can be bought quite cheaply at most stationers' shops. Fig. 5 shows an example of a pattern drawn on square-ruled paper.

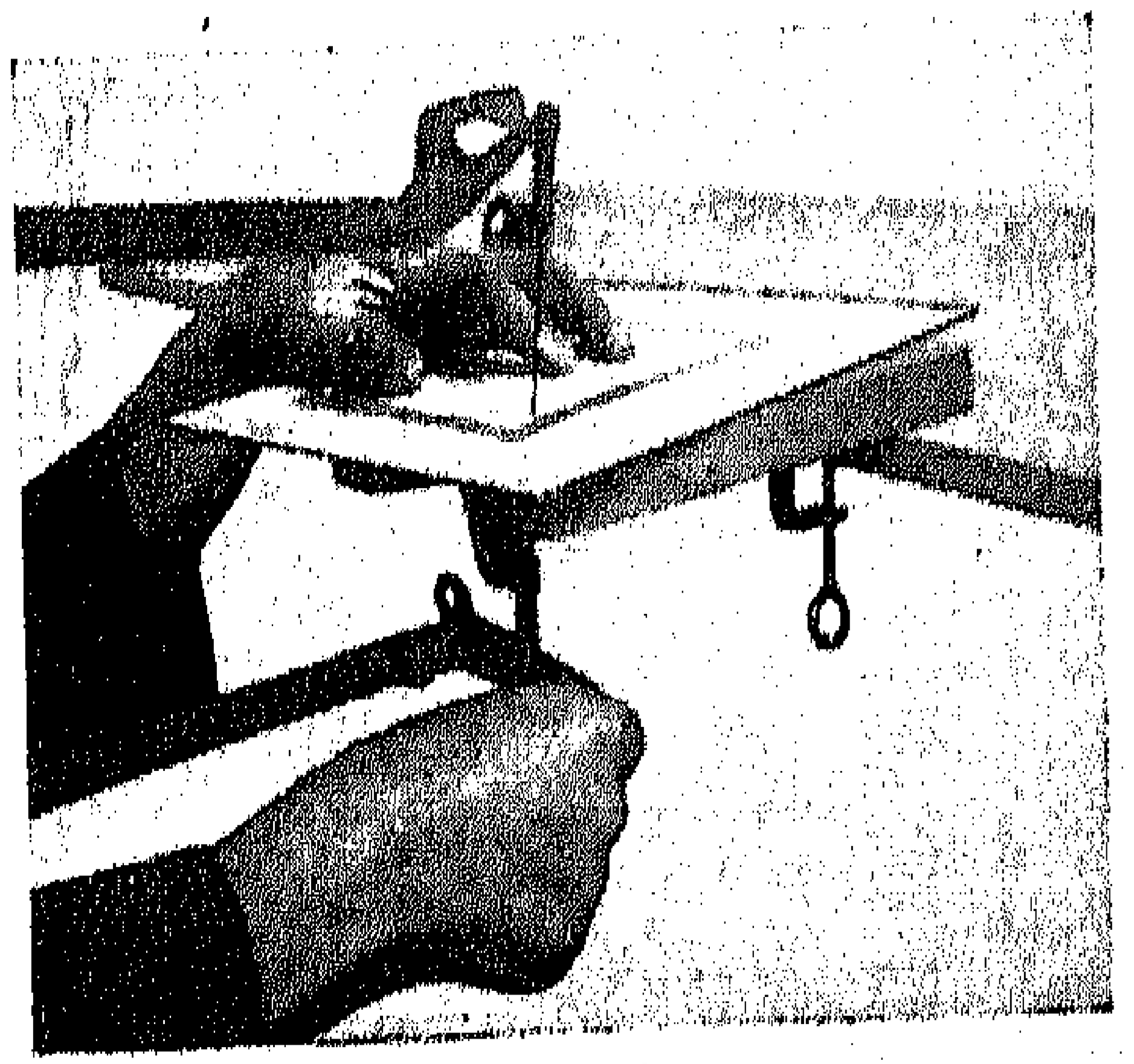


Fig. 6

Where carbon paper is used, place the prepared side of the paper down on the surface of the wood and lay the pattern sheet on top; then fasten it securely at each corner with a drawing pin. With a sharp-pointed, hard lead pencil, or the end of a fairly fine knitting-needle, trace over every part of the pattern. If you now remove the carbon paper you will find a well-defined outline plainly marked on the surface of the wood. Do not bruise the surface by pressing too hard.

Materials.—The material generally used in fretwork is thin hardwood, such as satin-walnut, mahogany, oak, etc. Deal and similar woods of a soft nature are not suitable for the purpose of the amateur.

Satin-walnut is perhaps the favourite wood for sawing as it is comparatively inexpensive, has a nice close grain, and is very easy to work. Its colour is a pleasing rich brown, and the boards can be obtained in wide dimensions, a distinct advantage when it is desired to fretsaw out a large design.

Plywood is also a useful material for the fretworker, but its use is somewhat limited owing to its rather unpleasing laminated edge.

Fretwood is generally planed up ready for use, the usual thicknesses being $\frac{1}{16}$ in. (planed on one side only), suitable for making delicate overlays, and $\frac{1}{8}$ in., $\frac{3}{16}$ in., and $\frac{1}{4}$ in., the latter being employed for heavier work. It is sold at so much per square foot (144 sq. in.).

Using the Saw.—Assuming that you have got the necessary tools together and a supply of fretwood to hand, and are ready to make a start, the first thing to do is to fix the blade, teeth downward in the hand-frame by slipping each end of the saw under the clamps and then tightening them up. The tension screw should be adjusted to pull the saw up tight, as a slack saw has a tendency to twist and break.

To gain a little experience in sawing and to accustom yourself to the "feel" of the tool, it is a wise plan to practise upon a few pieces of odd fretwork before attempting to cut out even a simple design. Pencil mark a few lines across the wood, some straight, some curved, and some with angles between them. Then try your hand at cutting along the lines in the following manner.

Place the wood on the cutting-table and hold the material down firmly with the left hand. Take the fretsaw and grasp its handle in the right, as shown in Fig. 6. Now bring the blade up against the edge of the wood where one of the straight lines begins, and work the saw up and down with smooth, even strokes, keeping the saw in a perfectly vertical position and, of course, cutting along the line. You will probably be astonished at the little effort required to propel the saw and surprised at the speed at which the fragile blade cuts its way neatly through the wood.

In curved work you should endeavour to turn the wood and not the frame, although you will find it an advantage at times to turn the saw, especially when working upon complicated designs.

One of the chief points to observe in cutting is to keep all angles sharp and well defined; otherwise they will probably appear as at A in Fig. 7. Two examples of negotiating angles are shown at B and C. In the one shown at B you saw from a drilled hole and arrive at the internal angle X from two directions as shown by the arrows. In sawing the external angle formed at X in C, the saw follows the upward curve to the point and is then run into the waste and continued round until it meets and follows the outline as shown by the dotted lines. By adopting these methods it will be seen that the angles are left sharp and clean.

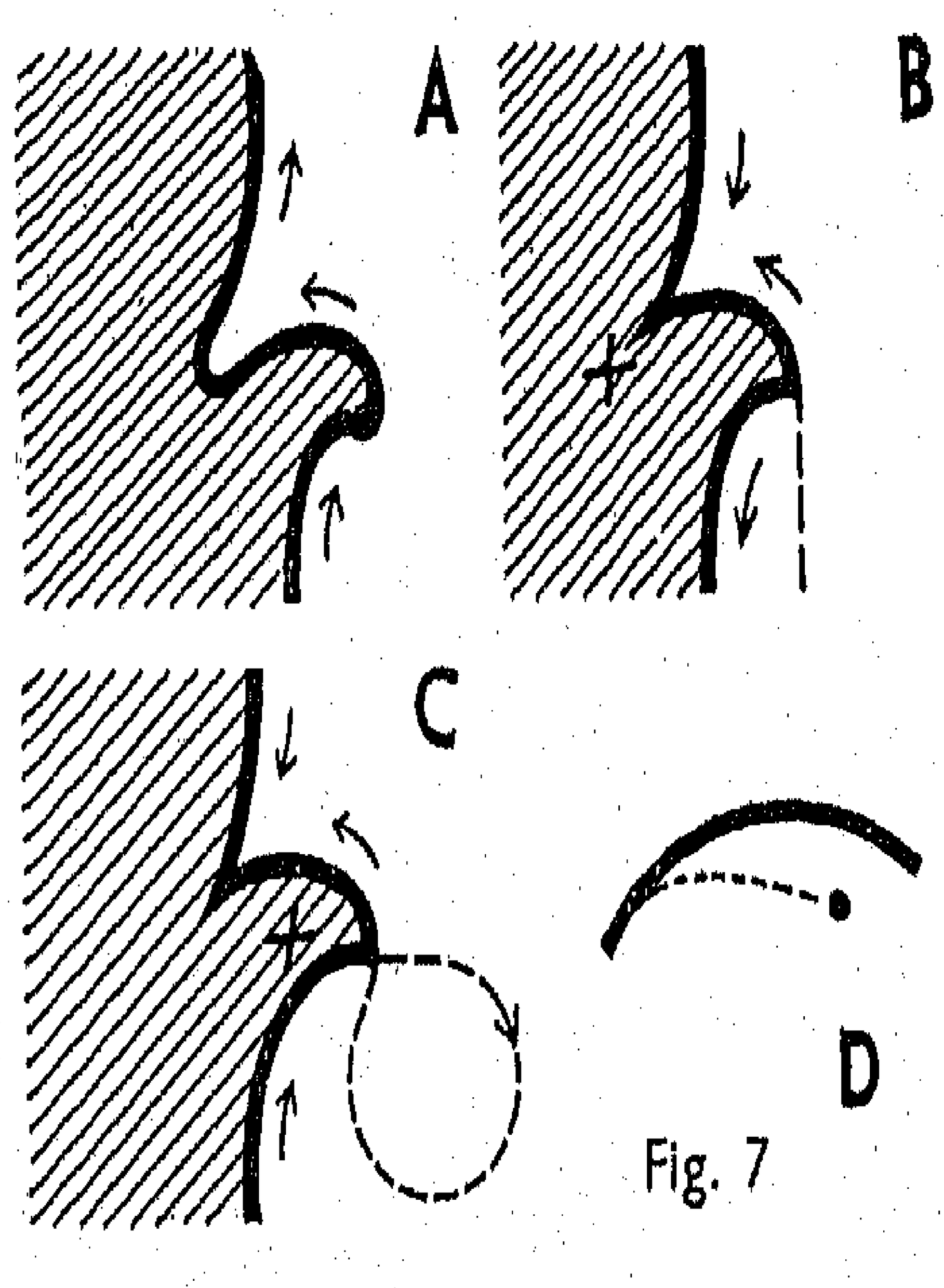


Fig. 7

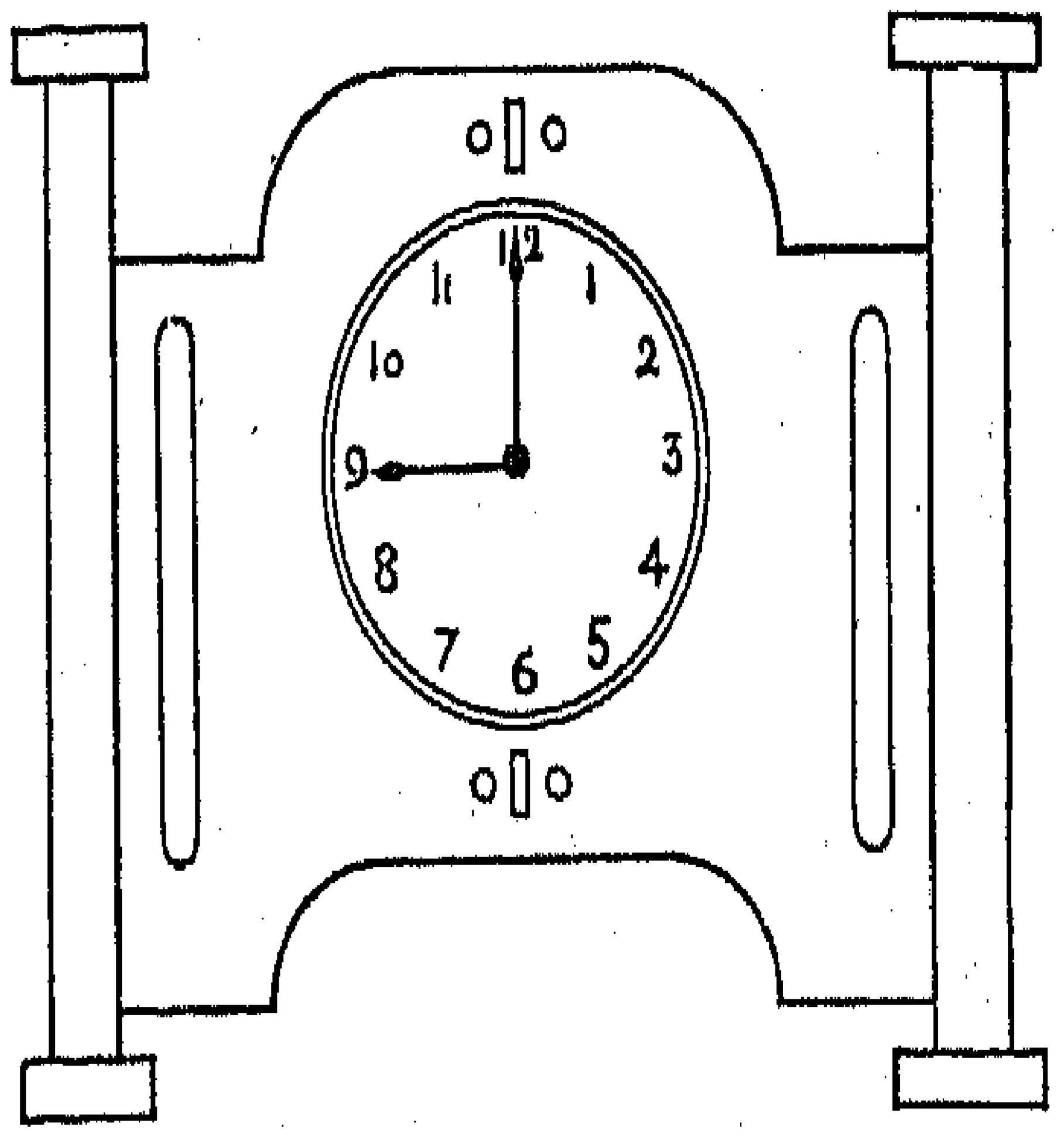


Fig. 8

In cutting a long curve as at D, the saw should take a gentle sweep to meet the curve to be cut. This is a much better method than sawing straight across the waste, and then making a very sharp angled turn with the tool.

Where it is found necessary to turn the saw, do it slowly, keeping the saw moving up and down the whole time.

It may be mentioned that if the saw is inclined to bind it generally indicates that it is too coarse, therefore, try a new blade. On no account should oil or grease be applied to ease the saw, as this may stain the wood.

Assuming that you can now cut the curved work out properly, and negotiate curves with ease, you will no doubt be anxious to take on something of a more ambitious nature. Buy or make a simple design such as a small bracket or other useful article as, for instance, that shown Fig. 8, before attempting to cut out a large complicated pattern.

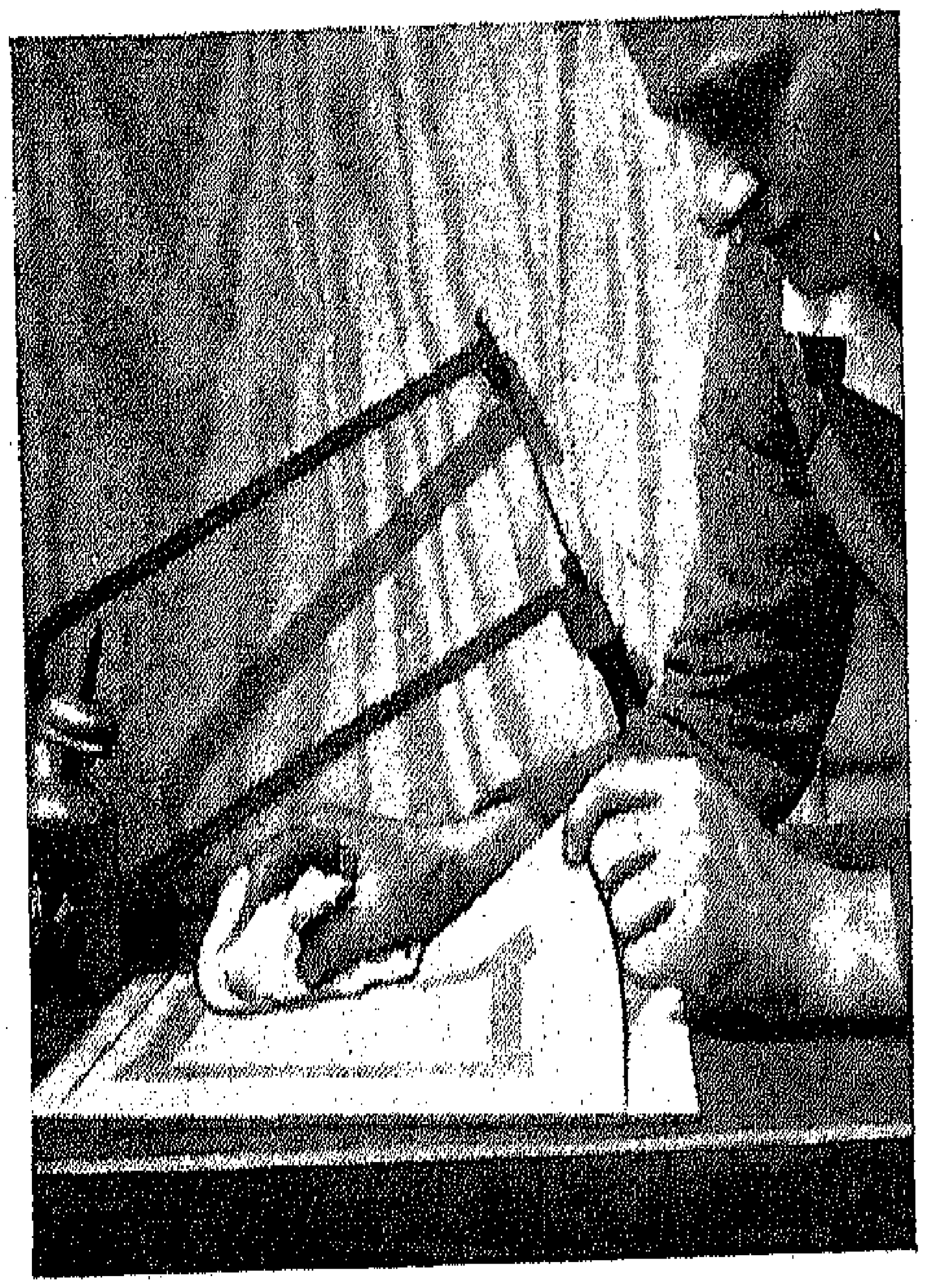


Fig. 9

Fixing the Pattern.—The first thing to do after having obtained a printed design is to read and carefully observe the instructions usually marked on the pattern sheet, as such instructions generally give details as to the best and most economical way to set the pattern out on the material. If these details are not given, proceed as follows.

Cut up the sheet into the various parts which go to make up the design, using a pair of sharp scissors for the purpose.

The pieces must now be fixed down to the wood. Before doing this, however, you should so arrange the parts of the design that the best use is made of the material without unnecessary waste, bearing in mind that the pattern should be fixed lengthwise to the grain of the wood.

When this has been done, apply a thin coat of paste to the surface of the wood and place the pieces of the design in position. Some workers prefer to paste the paper and fix it to the material, but this has the disadvantage of having to handle wet paper, which is not an easy matter. If this method is preferred, apply the paste radially from the centre to the edges to ensure an adequate supply to the edges.

Take a piece of soft rag or a clean duster and gently smooth the pattern down, taking care to exclude all air-bubbles, and then flatten out any wrinkles that may have formed. Fig. 9 shows the process.

Do not use ordinary tube glue or gum as an adhesive as you will possibly experience great difficulty when the work is ready for finishing. A good bought paste or a home-made one will do admirably.

A good home-made paste may be made as follows. Mix a small quantity of flour or starch into a stiff mass, using only a small quantity of cold water for the purpose. On this pour boiling water until you see it "turning" or jellifying. The paste is ready for use when cold. If the mixture does not jellify when the hot water is applied it usually indicates that either too much cold water was used in the first instance, or that the supposedly boiling water that was added was not boiling. This fault can sometimes be rectified by boiling the whole of it up again. As paste in this condition will not keep for long and quickly turns sour, the addition of a few drops of oil of cloves will act as a good preservative.

After pasting, the work should be placed upon a flat surface, and be allowed to dry; a few weights on the wood will prevent it from warping.

Drilling the Holes.—The next operation consists in drilling the holes in those portions of the design which are to be removed. The holes are necessary in order to pass the blade through. The Archimedean drill is used for this—never a bradawl; otherwise the wood is liable to split.

Drilling must not be attempted until the pattern is perfectly dry; otherwise the paper will pull up, or get distorted, if not badly torn.

It is a mistake to make the holes too small, as difficulty will be experienced in passing the saw-blade through the wood.

The best way to carry out the drilling is first to place the work on a piece of waste flat wood to prevent the drill breaking the fibres on the underside, and then lightly fasten both the work and the support to a flat surface, such as a kitchen table-top. This allows both hands to be free to operate the drill, as illustrated in Fig. 10. The fastening can be achieved by partially driving in a few thin panel pins here and there in the waste part of the design.

After all the necessary holes have been carefully drilled, apply a piece of glass-paper to the back of the work to smooth down any lumps that may have been made by the bit.

Most saws are broken in one of two ways. One is the result of attempting to saw too quickly round corners, and the other is generally due to carelessness when inserting and fastening the blade under the fixing clamps of the frame, after the blade has been threaded through one of the drilled holes in the waste. In refixing the blade always see that the ends of the blade are perfectly straight and not bent before tightening the clamps. Failure to observe this simple precaution invariably leads to a broken blade.

Removing the Waste.—Cut out all the waste material from the interior of the design and then proceed to cut out the outline. This is a much better method than cutting the outline first, as the outside material greatly assists in strengthening the work whilst the interior is being cut. The sawing operation should be done very carefully to avoid risk of breakage.

Removing the Pattern.—Having completed the sawing out, the next thing to do is to remove the paper pattern from the surface of the wood.

A certain amount of the paper may be pulled up with the fingers, but the remainder should be removed by means of the glass-paper block.

Do not use water on any account, as it will cause the wood to curl and buckle, and perhaps ruin your handiwork.

Put a piece of No. 1½ glass-paper in the block, and when the pattern is rubbed off, finish the work with a finer grade of paper.

Give the back of the work a good glass-papering to remove the saw-kerf, and if any little lumps appear on the edges, rectify them by using a very small file of suitable shape.

Should the work be very small, as in the case of brackets for supporting shelves, it may be an advantage to fasten down a sheet of glass-paper on to the face of a smooth board and rub the work on the papered surface. The paper can be attached to the board by using drawing pins at the corners, or it may be glued down. Care is needed when this method is adopted to see that the supporting

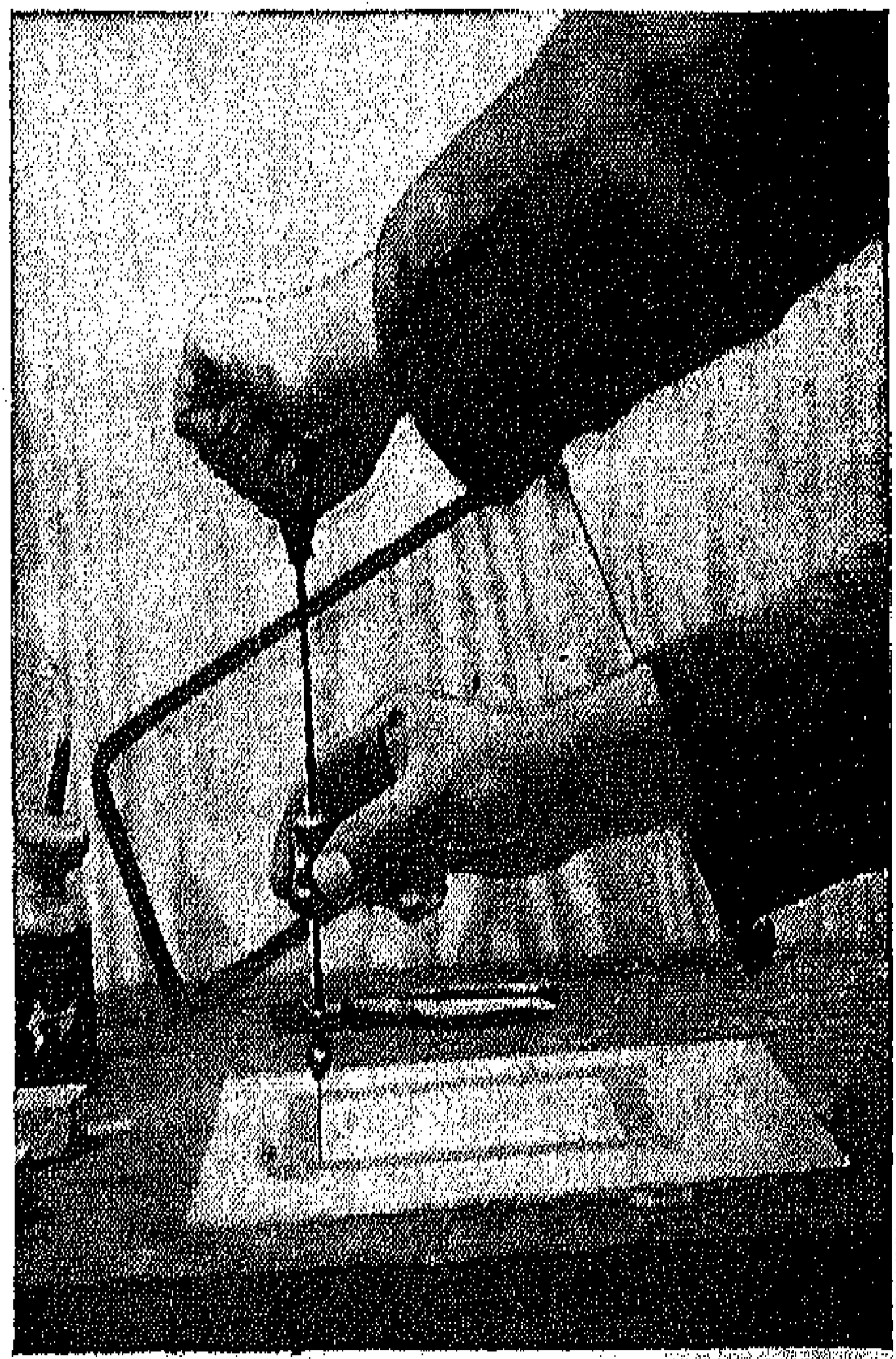


Fig. 10

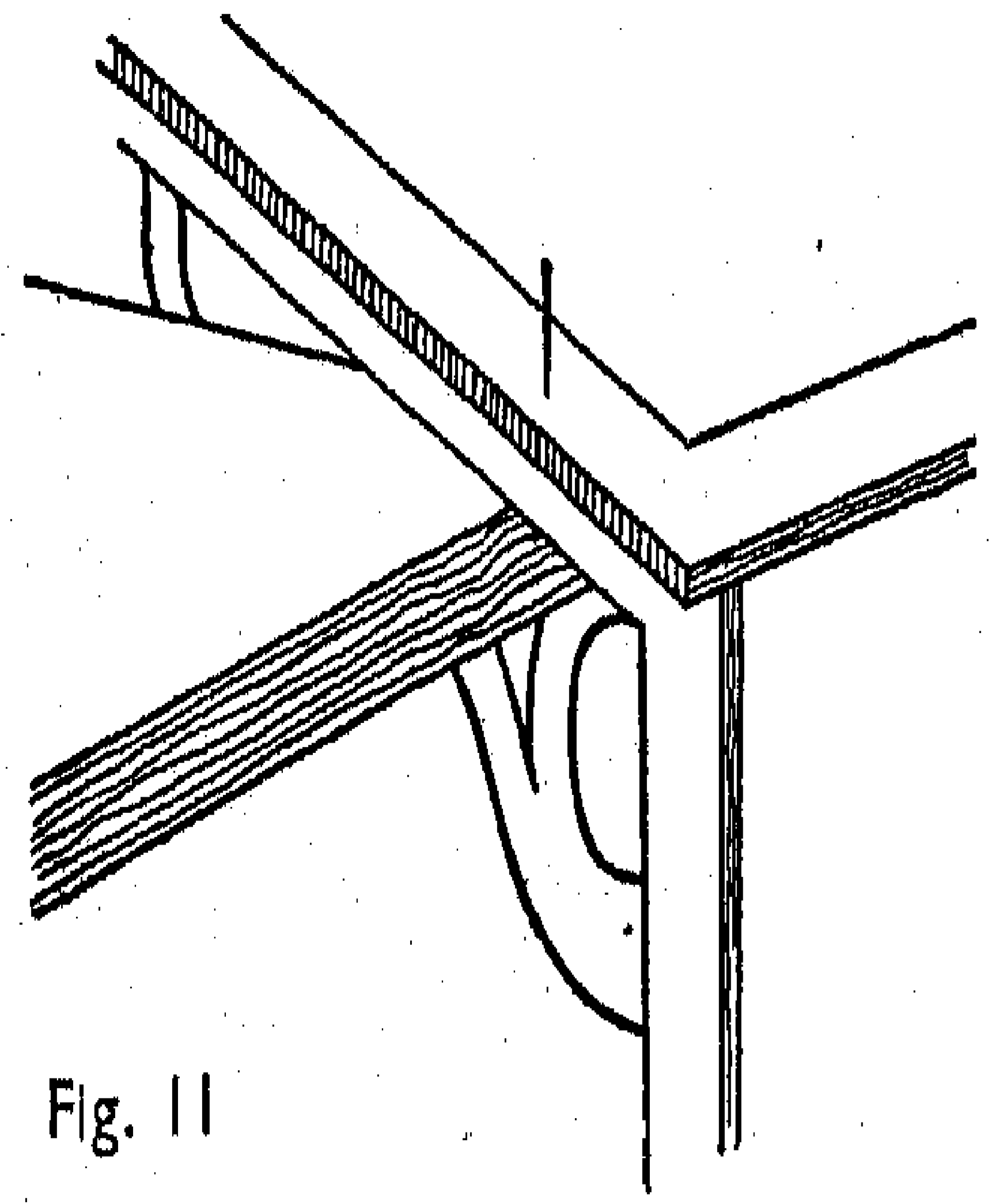


Fig. 11

surface is perfectly smooth and flat, because any little projection or unevenness may possibly force up a delicate part of the work and break it off.

Assembling the Parts.—The various parts of the article in hand may now be assembled in accordance with the printed instructions on the design sheet.

Special care should be taken when fitting the parts together, as a lot of trouble and disappointment can be easily avoided by taking simple precautions and exercising a little patience. All joints should be a nice, easy, hand-tight fit, and on no account must the pieces be forced together. If a slot is a little too narrow, ease it with either a fine file, or a piece of glass-paper wrapped round a small piece of wood. The same thing applies if the corresponding projecting pieces happen to be a little too "full."

Liquid glue is an excellent adhesive to use for fastening the parts together, as it is not only exceptionally strong, but is easy and clean to manipulate.

In some cases it may be found that glue is not sufficiently strong to make a firm joint, and it may be necessary to resort to the use of screws or nails.

When nailing or screwing, see that the part to be fastened is solidly supported. Fix a stiff iron bracket or something of a similar nature in the vice, and hold the solid part of the fret on this by allowing the projecting end of the metal to enter an opening in the fret close to the edge. The corner of a table may answer the purpose quite well provided the fret is a very open one, as shown in Fig. 11.

Fine veneer pins, or ordinary pins minus their heads, will generally suffice for nailing; but if screws are used do not forget to take the precaution to drill the wood before inserting them.

USEFUL WORKSHOP APPLIANCES

ONE of the first accessories the amateur should make for himself is a straight-edge, illustrated at A in Fig. 1.

This device should be made from a piece of hardwood, preferably Spanish mahogany, as this wood can be relied upon not to twist and shrink like a good many hardwoods, such as oak.

A convenient size for general purposes is 2 ft. long, 4 in. wide, and ¼ in. thick.

Plane one edge perfectly true, and test this edge by first drawing a line on a clean piece of board, using the edge as a guide, and then turning the straight-edge over laterally. If the newly presented edge corresponds with the drawn line it indicates that the edge is true.

Bevel off the top corners, as shown in the illustration, so that no mistake will be made as to which is the true edge when it comes to be used, and bore a hole near one end to enable it to be hung up out of harm's way when not in use.

Never be tempted to use a straight-edge as a guide for a knife or chisel, but only for the purpose for which it is intended, that is, for testing planed surfaces.

If the appliance rocks on the surface being tested, it indicates that the surface is high somewhere near the middle; and if light can be seen between the working edge and the work it shows that the surface being planed is hollow.

Winding Strips have been mentioned elsewhere for testing whether a board or a framing has a twist in it or, as it is technically termed, gone into winding.

Two winding strips are needed which, like the straight-edge, should be made of mahogany.

Such winding strips, an illustration of which appears at B in Fig. 1, can be about 16 in. long, 1½ in. wide, and ½ in. thick.

In making this appliance great care must be taken to see that the long parallel edges are perfectly true. Gauge carefully and true carefully, and after preparing to satisfaction, turn them end to end to see if they coincide exactly as to width. Bevel off the top edge, as shown in the illustration, leaving the full thickness of the bottom one to enable the strips to stand upright. The bevel should be planed to leave about ¼ in. on the top edges to sight along when in use.

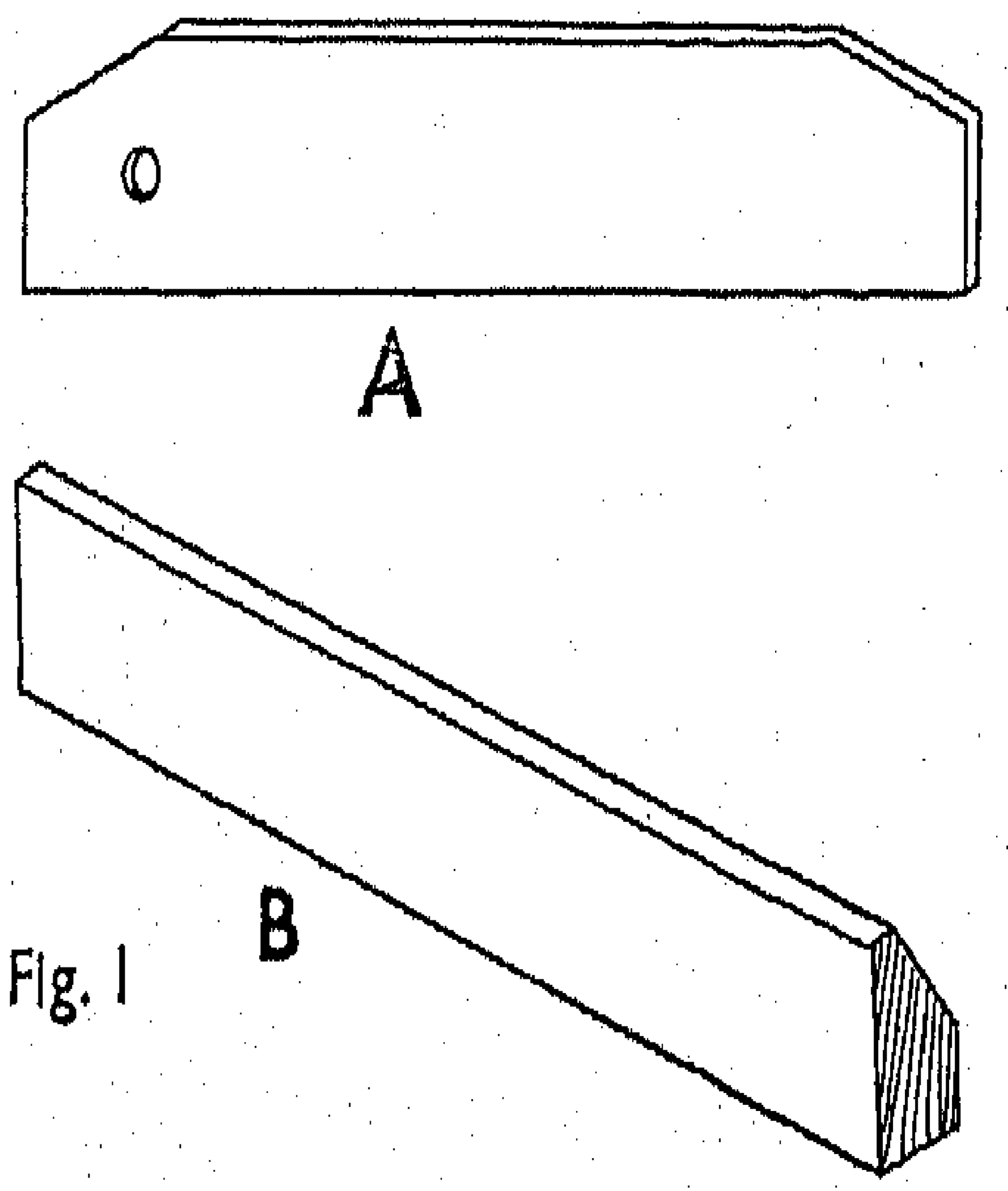


Fig. 1

A Sawing-stool is a very useful adjunct to the woodworker's equipment and is a much more satisfactory device than the usual makeshift box. If the worker feels so disposed he can make two sawing-stools, as the extra one will be found extremely useful when dealing with long lengths of timber.

The sawing-stool shown in Fig. 2 is quite simple to construct and will give a lifetime's service if properly cared for.

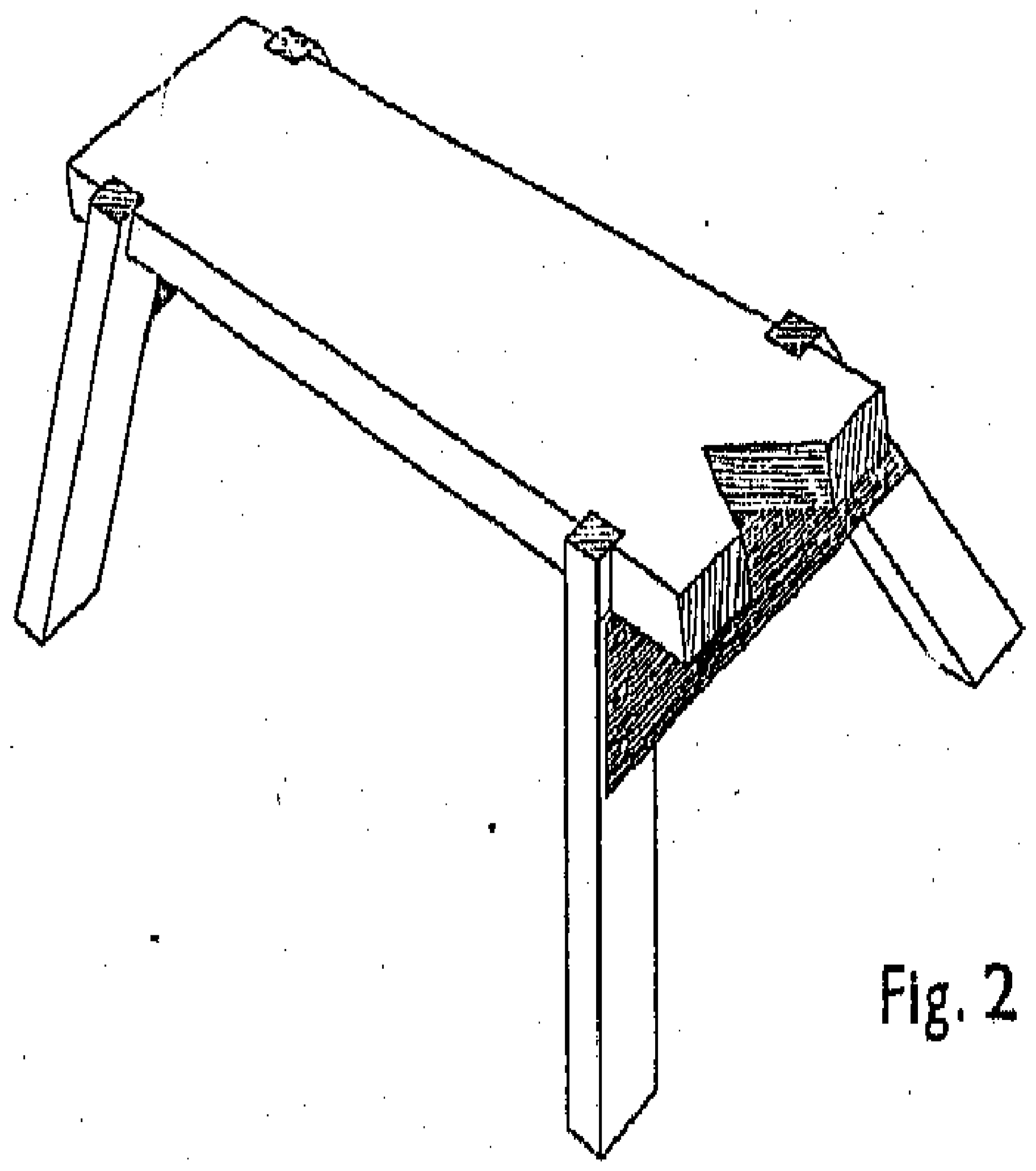


Fig. 2

The top member is a piece of good-quality yellow deal, 2 ft. 6 in. long, 6 in. wide, and 1½ in. thick. A V-shaped cut should be made in one end as the two projections so formed steady the material when the saw approaches the end of the cut.

The legs can be made from 3 in. by 1½ in. material; and if these are made 20 in. in length, they will provide for a stool that can be used comfortably by the worker of average height. The tops of the legs should be marked and cut out to form a shoulder to support the top member, and let into the sides in the manner shown in the drawing. To strengthen the legs and prevent them from pulling outwards, a piece of 6 in. by ¾ in. board, cut to suit the splay of the legs, should be fitted across them at each end, and fastened by means of screws.

A Shooting-board is another useful appliance which the amateur can make for himself. A properly constructed home-made shooting-board is much to be preferred to the cheap ones that can be bought for a few shillings. As a rule such devices are merely made up of two boards screwed together, or from one thick piece having a rebated edge. This method of construction has the disadvantage that the wood easily twists and shrinks, and therefore soon becomes inaccurate.

Fig. 3 illustrates a shooting-board that is not at all difficult to construct and will give satisfaction for a lifetime.

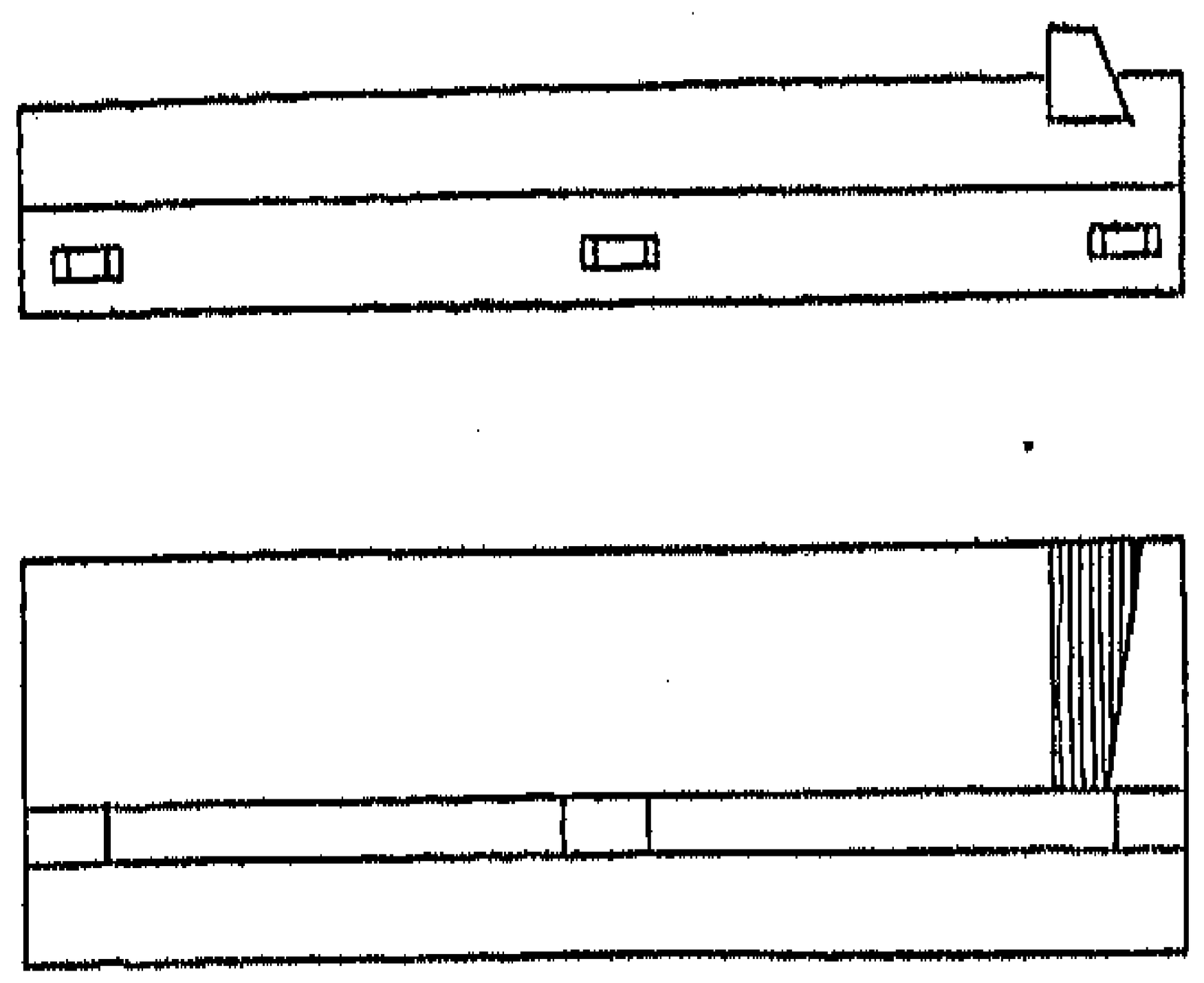


Fig. 3

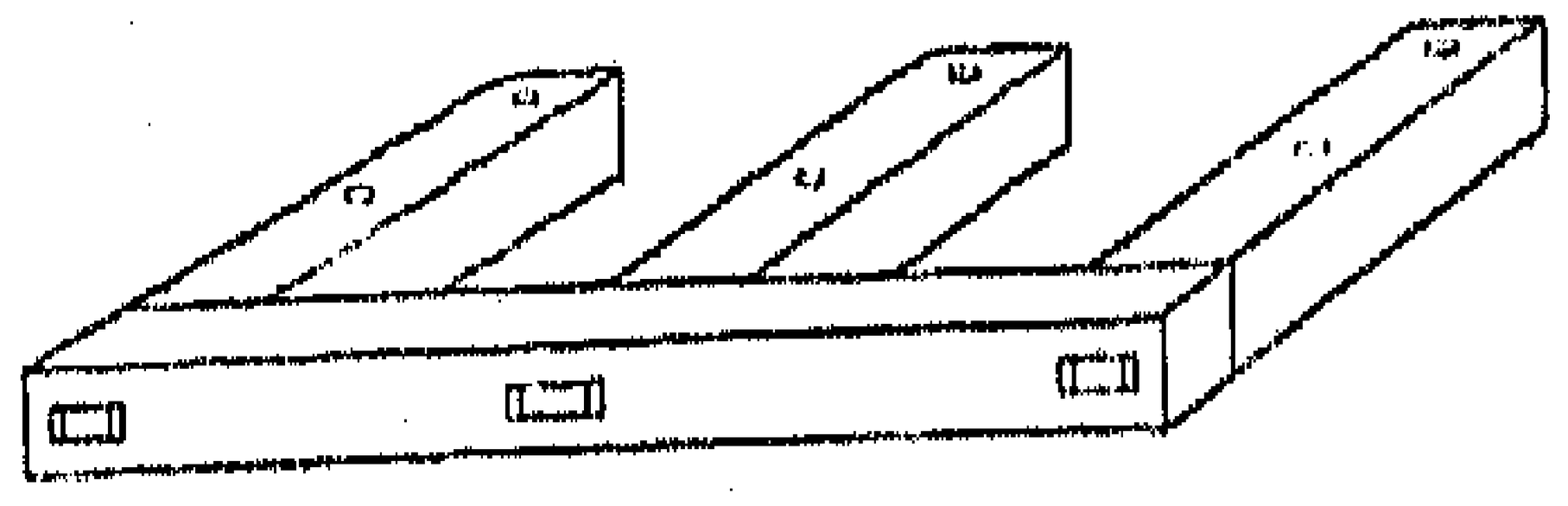


Fig. 4

Obtain $5\frac{1}{2}$ ft. of 1 in. by $1\frac{1}{4}$ in. best-quality yellow deal, free from knots and other defects. Buy it ready planed, but test it before use and true up any little bit of twist that it may have acquired. This is absolutely necessary, because the material, although trued up and planed in all good faith by the timber merchant, may have developed a twist by the time the material is called upon for the job.

Cut the length into four pieces: one 3 ft. 1 in. long, and the remaining 2 ft. into three equal lengths. The extra inch on the long length is to allow $\frac{1}{2}$ in. at each end for safety when cutting the mortice, and can be trimmed off afterwards, if so preferred.

Mortice and tenon the pieces together to form a sort of framework, as shown in the illustration (Fig. 4), and when complete test for twist end to end and each end to middle. Then trim up with a plane to a finished thickness of $\frac{7}{8}$ in., and cut the legs to a length of 7 in.

True up a piece of faultless prepared yellow deal board, 3 ft. long by 5 in. wide and 1 in. thick. Drill two or three equidistant holes in each leg of the framing to take No. 8 countersunk-headed screws, $1\frac{1}{2}$ in. long. Countersink the tops of the holes fairly deeply on the underside to enable the heads of the screws to lie well below the surface to prevent them from scratching or catching anything.

Screw the parts together as shown in the plan—the lower drawing in Fig. 3.

A small space is left between the working edge of the board and the long member of the frame to allow shavings to slip away out of the course of the plane.

Next prepare the stop, which should be made from a piece of hardwood. Note the shape. On looking at the elevation and plan it will be seen that the stop has two bevels, but the front face, against which the work to be planed will rest, is left square. The height is of no great consequence as long as it provides a stop.

Having completed the stop, its position can be scribed on the board against a line drawn across the top with the aid of a square. When the recess has been carefully cut out, fit the stop by means of glue and screws, and trim off the front edge to allow free running of the plane.

The trying-plane is generally used on

a shooting-board. When using the board it is advisable to plane to a scribed line marked on the work even if the device is accurately made.

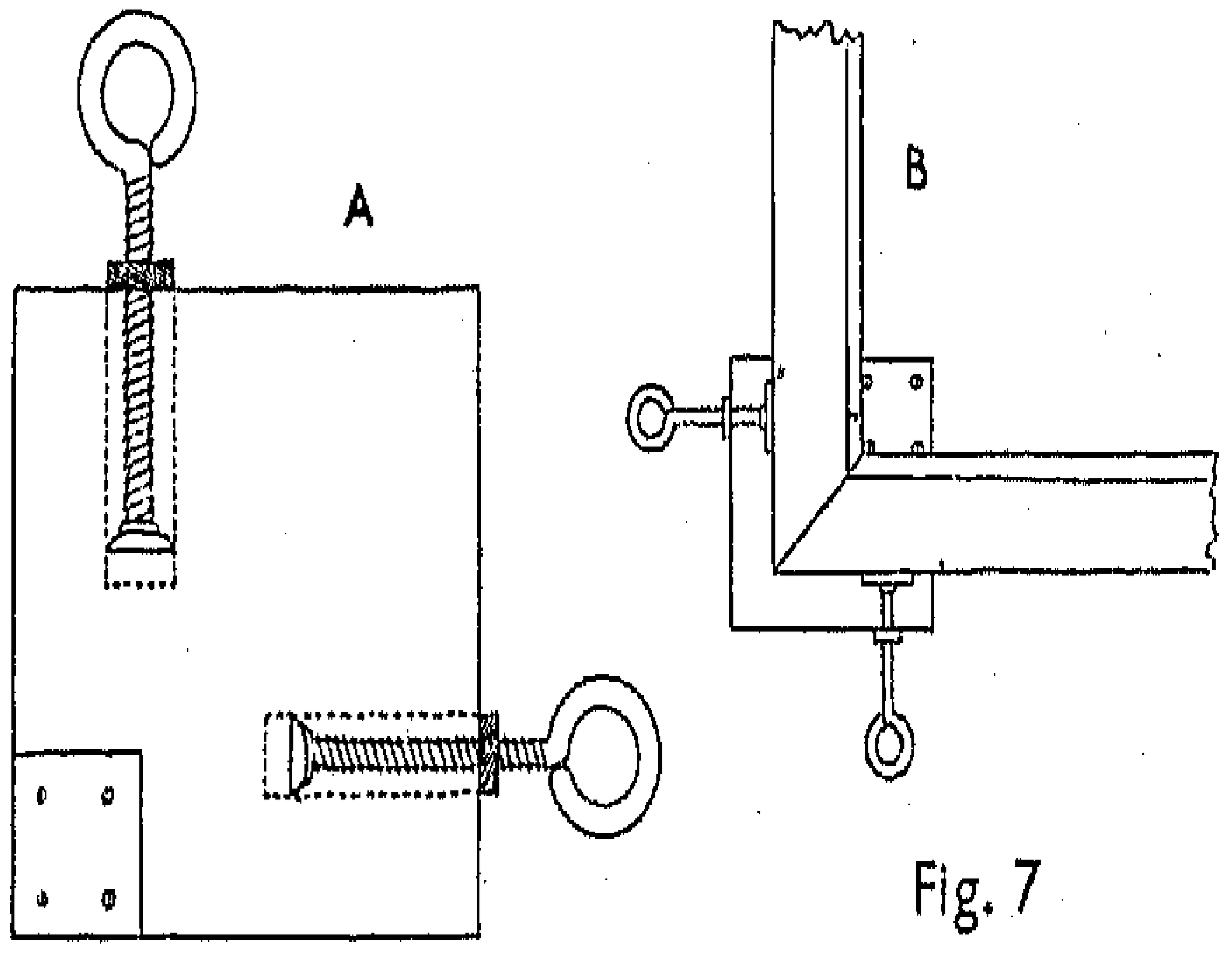


Fig. 7

The Mitre Shooting-board shown in Fig. 5 is made on similar lines to the ordinary one just described, the main difference being that only two legs instead of three are necessary for the framework, due to its shorter length, and that two stops fixed at an angle of 45°, in the middle of the mitre shooting-board, take the place of one right-angled one.

To construct such a board, about 4 ft. of 1 in. by $1\frac{1}{4}$ in. deal is framed up as shown. The front member is 2 ft. long. The mortices can be made in it at a distance of about 2 in. from each end to take the legs, which are 9 in. in length overall. Screw the back part of the frame to a piece of trued-up board, 2 ft. in length, 7 in. wide and 1 in. thick.

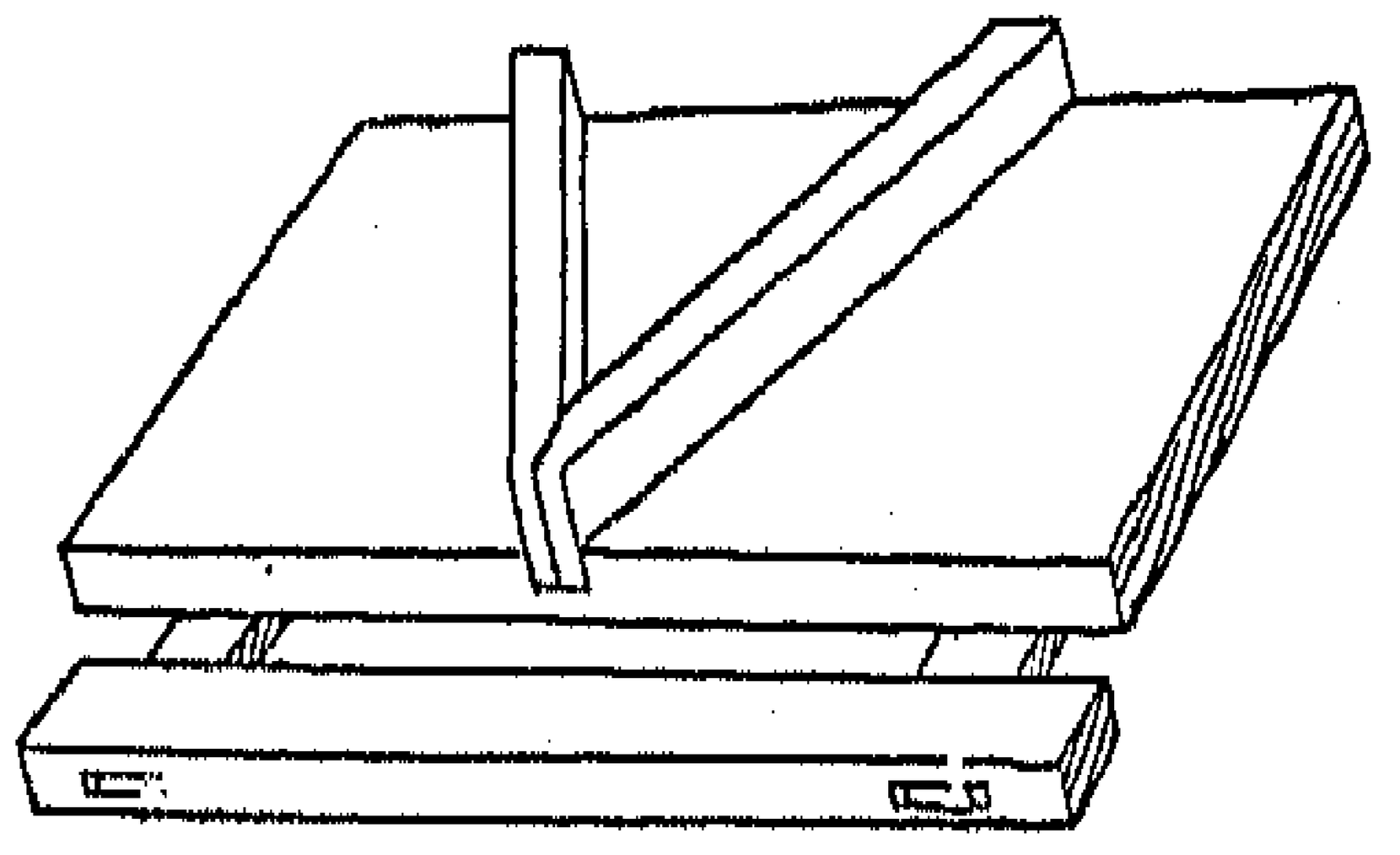


Fig. 5

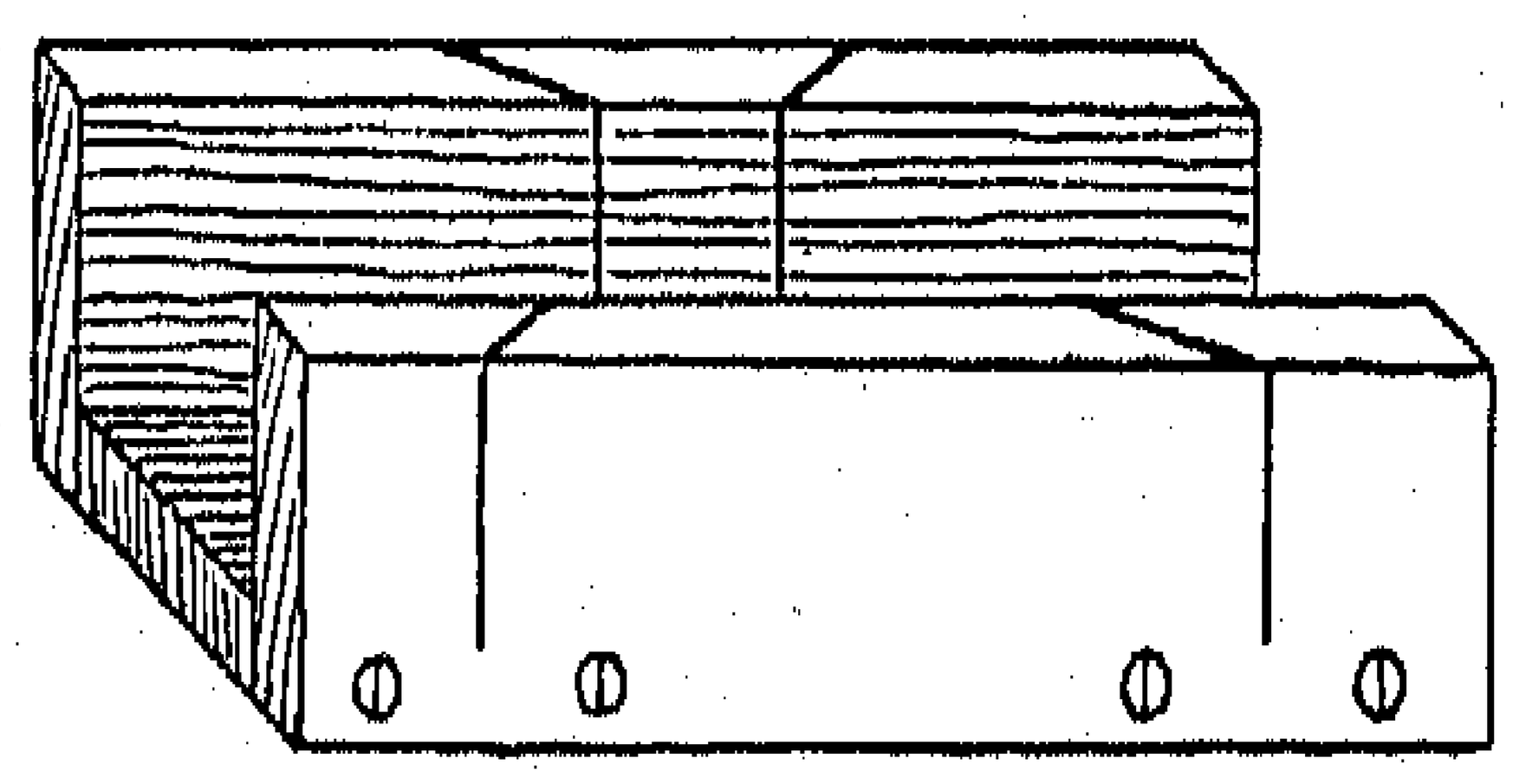


Fig. 6

From a centre line scribed on the front of this board mark off a distance of $\frac{1}{2}$ in., and from these two points scribe lines at an angle of 45° to the front edge.

To make the stops, an 18 in. length of 2 in. by $1\frac{1}{2}$ in. hardwood will be required.

From the lines already scribed, and using the narrow edge of the hardwood as a guide, scribe two more lines parallel to the first two, and remove the waste to form the recesses. These should be about $\frac{1}{4}$ in. deep and can be made either with a chisel or a router.

When this operation is finished, glue and screw the stops in position as shown in the illustration, finally trimming off any unnecessary projections.

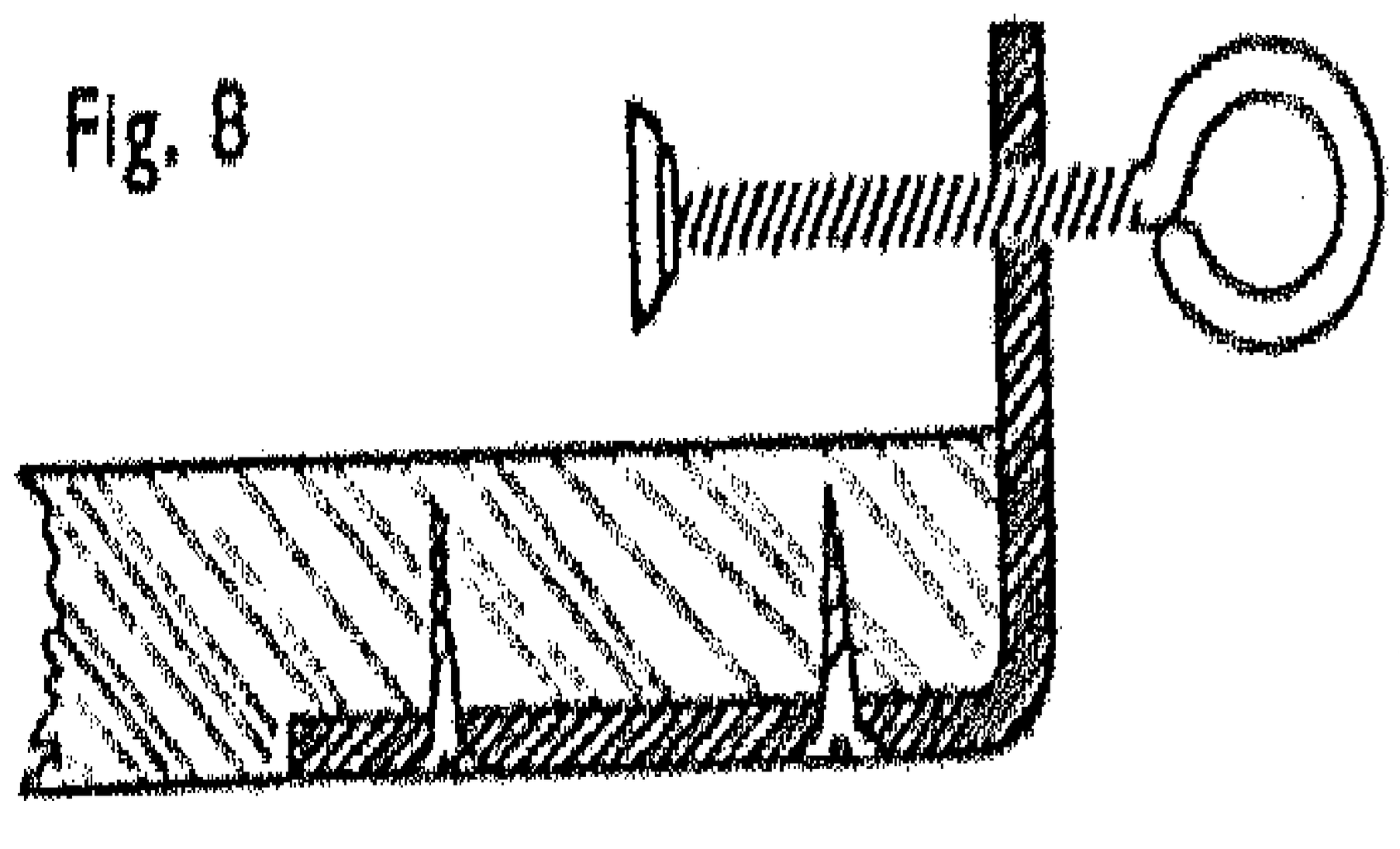
The Mitre-box illustrated in Fig. 6 is looked upon by many workers as a better means of cutting a mitre than a mitre-block. In the case of the mitre-box the saw is guided on both sides of the material that is being mitred, consequently a more correct cut is obtained.

Such a box, suitable for cutting mouldings up to 3 in. wide, can be made with a prepared piece of yellow deal, 18 in. long, 4 in. wide, and at least 1 in. thick, to form the base, and two pieces of $\frac{3}{4}$ in. stuff, each 18 in. long and about 4 in. wide, for the sides.

True up the pieces and screw them together, using stout screws for the purpose, and then mark and saw the two slots at an angle of 45°, as shown in the drawing.

In fixing the positions of the screws, do not allow any of them to come in line with the saw-cuts.

The Corner Cramp.—Fig. 7 (A) shows this useful appliance, which will enable the handyman to overcome the difficulty of holding right-angled mitred work when gluing and nailing. Such a device will be found exceptionally useful for making picture frames, four cramps being necessary.



The principle upon which the cramp works may be gathered from a glance at B in Fig. 7, which is self-explanatory.

The base can be made out of a piece of oak, or other hardwood, about 4 in. square and ¾ in. thick. A small piece of ½ in. hardwood, 2 in. square, is fastened to one corner of the base by means of screws.

The tightening screws on the two adjacent sides consist of small fretwork cramps with the long end opposite the screw removed. Two holes are drilled in suitable positions to enable these parts of the cramps to be screwed into recesses cut in the underside of the base, as shown in detail in Fig. 8.

A hacksaw can be used for removing the long leg of the cramp or, failing this, a file can be employed. If the latter method is decided upon, first cut a deep nick in the top and bottom surfaces by the aid of a half-round file used edgewise, and then give the leg a smart blow with a hammer. Complete the job by filing the end square.

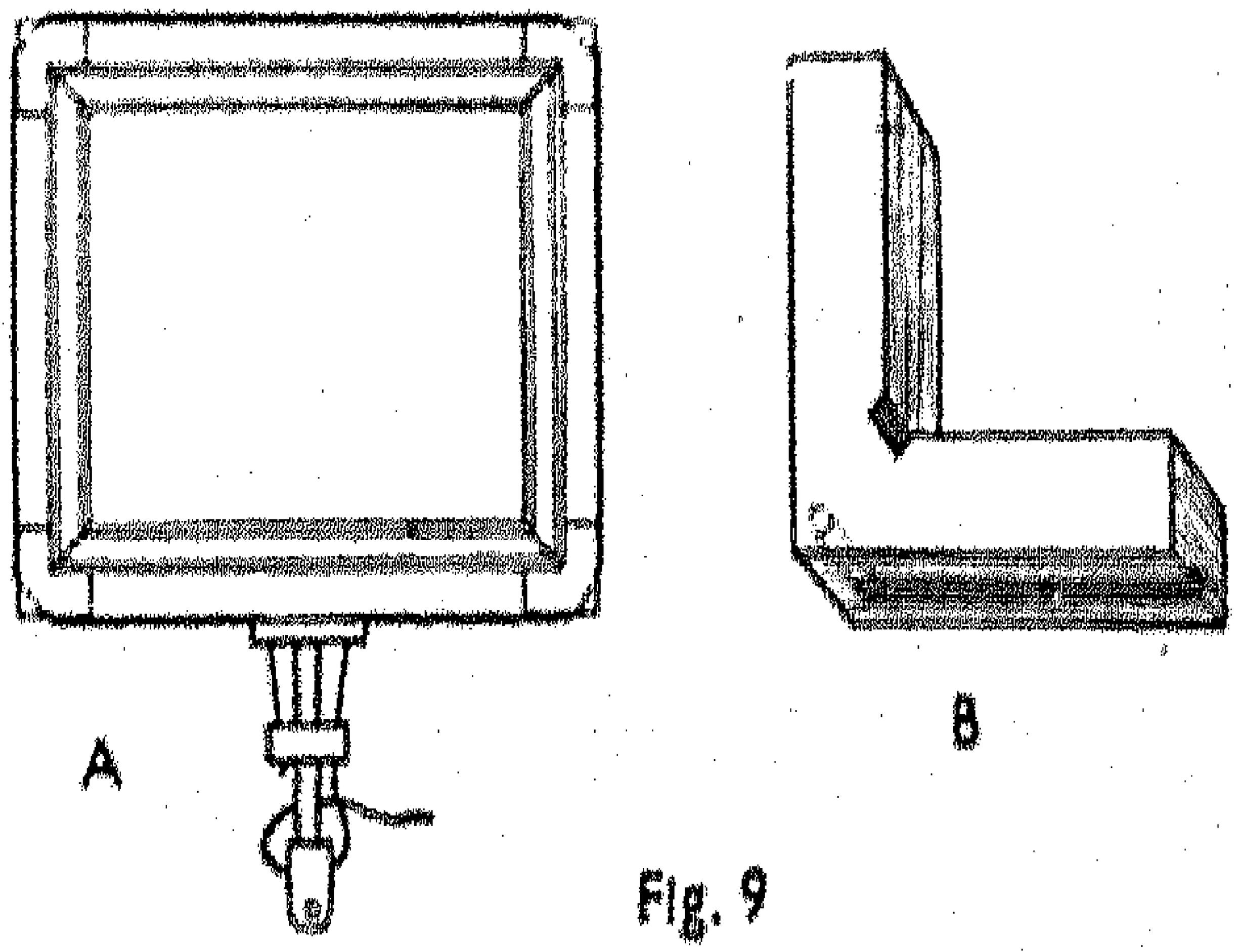


Fig. 9

To use the device, glue the pieces to be joined and place the mitred corners in the cramps so that the rebate (if a picture-frame) engages with the projection on the base. Insert slips of wood between the outer edges of the moulding and the ends of the screws to prevent damage, and tighten up the hand screws.

Another Form of Cramp for mitred work is shown at A in Fig. 9 in which four corner blocks made of hardwood, such as oak, beech, etc., are used. A corner block enlarged is shown at B in the illustration so that the method of preparing it can be better understood.

Each limb of the block is about 3 in. long by 1 in. thick, and is L-shaped. The corner forming the internal angle is recessed as shown. A hole is bored through the outer corner to take a stout piece of cord, which lies in a shallow channel formed in the two long edges. The hole and groove can be omitted if desired, but it is not advisable.

The tightening screw is an ordinary wood hand-screw and nut cut from a cramp, which can be purchased for about a shilling at most woodworkers' stores.

A hole is drilled near each end of the nut, and a piece of hardwood about 3 in. long, 1½ in. wide, and ½ in. thick takes the point of the screw, which is also provided with similar holes. One end of the cord is knotted, while the other end passes through one of the holes in the nut and bearer, through the blocks and opposite holes in the bearer and nut where it is securely tied, after the blocks have been placed in position. A few turns of the screw tighten the cord and the resulting pressure on the blocks efficiently cramps the joints of the work.

The screwing may be eliminated if desired by substituting a block of wood or wedges between the frame and the tied cord, but this method of obtaining the necessary tension is not so satisfactory as the screw.

Fig. 10 illustrates a useful device for forming small depressions or beads along the edges of a piece of work. It consists of a cutter fixed in a suitable handle.

A piece of oak or other hardwood, 1 in. by 1½ in. and about 10 in. long, is sawn down the narrow edge for a distance of about 3 in., and a shoulder cut as shown, the remaining part being shaped to form a handle.

Suitable screw-holes are made at intervals along the side of the slotted portion to take ordinary wood-screws which, when tightened, hold the cutter firmly in place.

The Cutter or scraper—it is more of a scraping tool than a cutting tool—is made from an odd piece of steel, such as a piece of hacksaw blade filed to the desired shape after it has been softened by heating it to redness and then allowing it to cool slowly. After filing, the cutter should be hardened by heating it up to redness again and then quenching it in water. In filing the cutter it is necessary to "back off" the cutting edge in order to present a sharp edge to the work.

To use the device, insert the cutter into the slot at the desired distance from the shoulder, which acts as a distance guide, and tighten up the screws. Work the tool in the direction of the grain, keeping the shoulder pressed up tightly to the edge of the work. Do not attempt to form the bead in one cut, but gradually develop the formation of the bead by taking several strokes, pressing the cutter a trifle deeper into the material at each subsequent stroke.

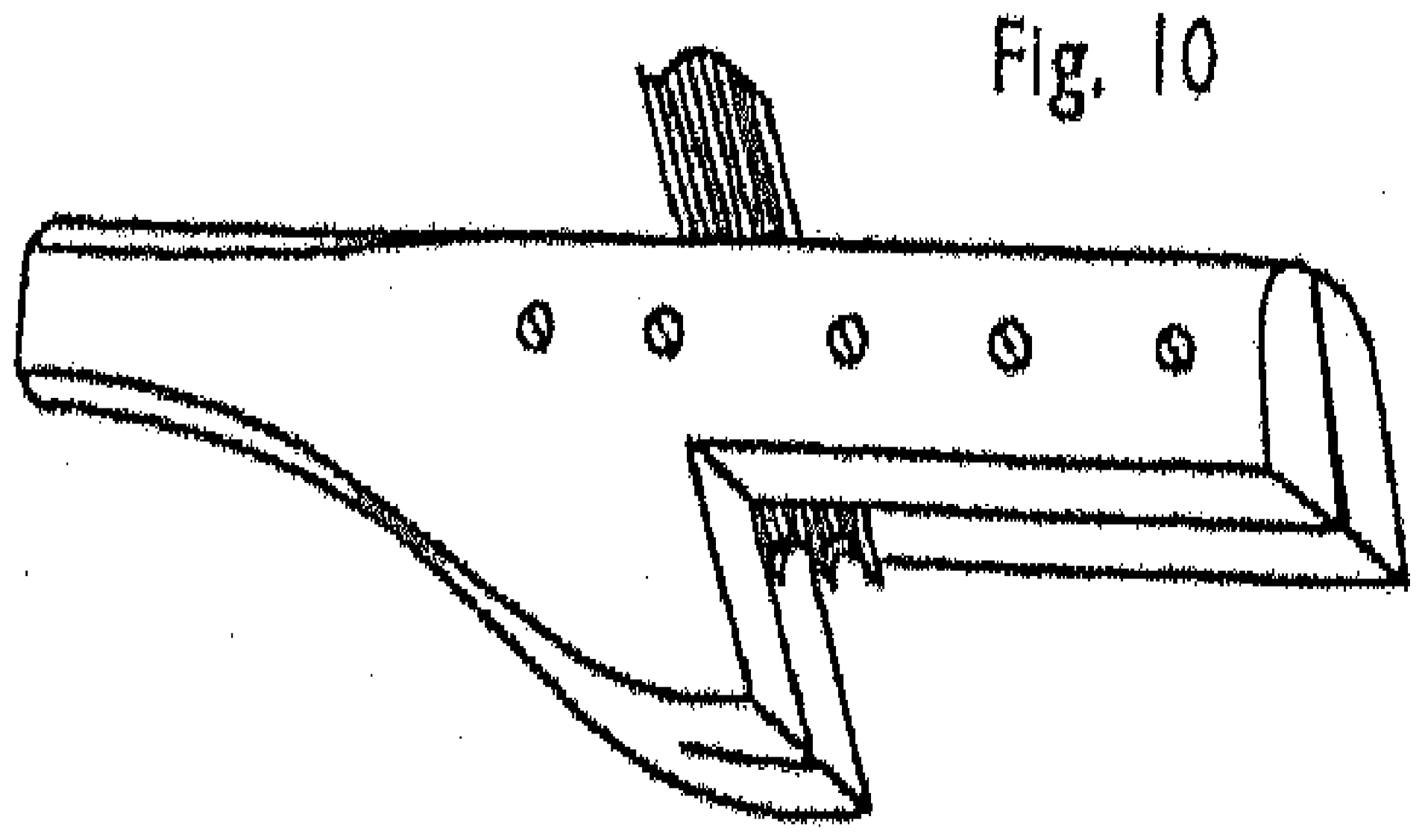


Fig. 10

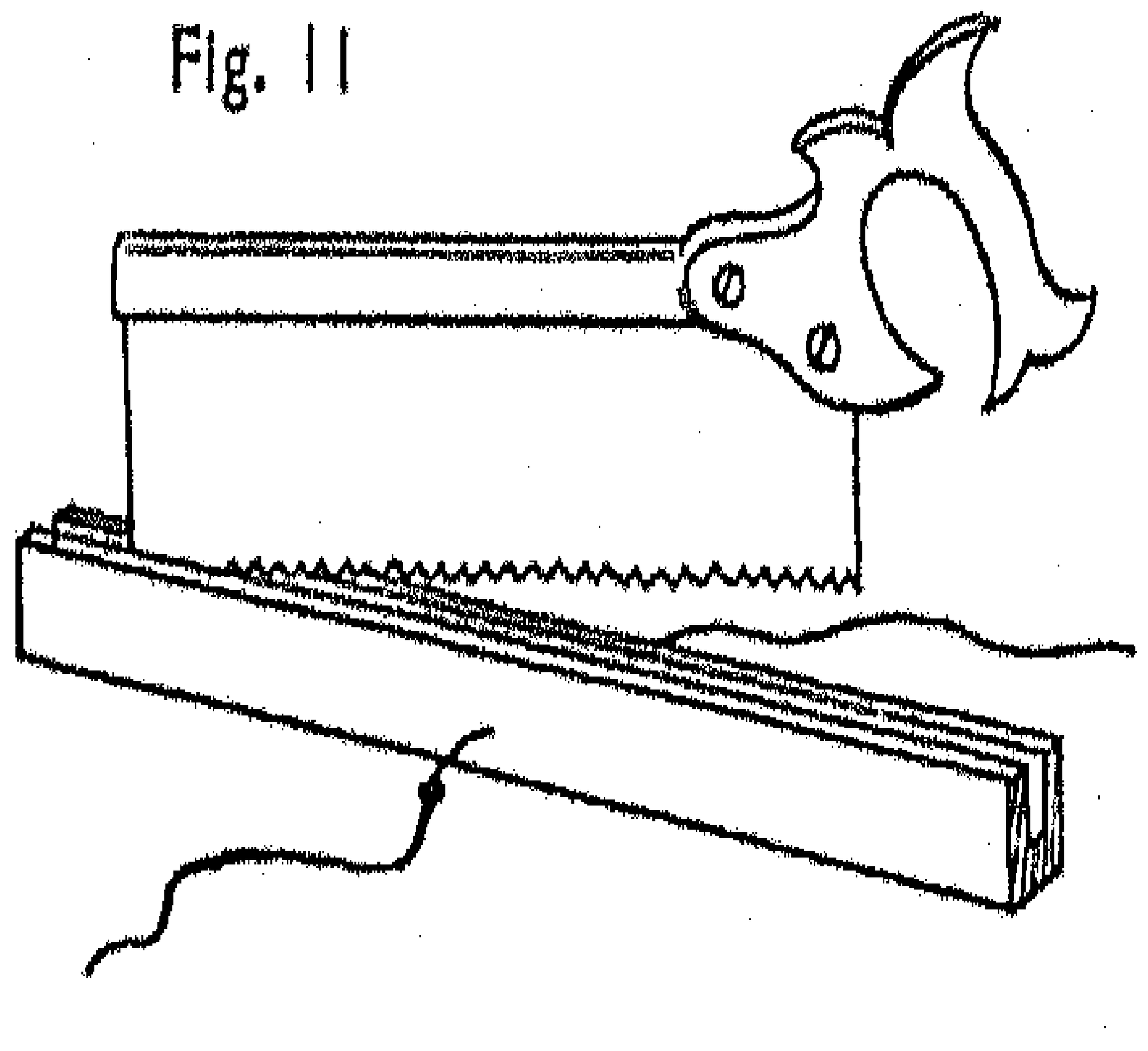


Fig. 11

The illustration shown in Fig. 11 is of an accessory for protecting the teeth of a tenon-saw fitted with an open handle which does not allow of easy hanging on a nail after use. It consists of a strip of hardwood a trifle longer than the blade of the saw. A saw-cut about ½ in. deep is made in one of the long narrow edges, into which the teeth of the saw are inserted. A hole is bored through the centre of the strip through which a suitable length of cord is threaded and knotted at each side to prevent it from being pulled through.

When the saw is not in use, the teeth are slipped into the saw-cut and the cord tied over the back to keep it in place.

An ordinary household flat-iron firmly secured between the jaws of the bench-vice, so that the sole is uppermost, forms a convenient anvil.

ARRANGING THE WORKSHOP

In estimating the size of a garden workshop much depends, of course, upon what it is going to be used for, remembering that it is poor economy to build the workshop too small.

If light woodwork, such as cabinet-making, fretwork, etc., is to be undertaken, a workshop about 10 ft. long by 7 ft. wide and 6 ft. high at the front and 7 ft. 9 in. at the back will generally answer the purpose, but where work of a larger nature is to be carried out, and perhaps a lathe installed, a more commodious structure is necessary.

Size.—A structure 18 ft. long by 10 ft. wide, built to a height of 7 ft. 6 in. to eaves and 8 ft. 6 in. to ridge, and fitted with double doors at one end, will give room not only for accommodating the usual woodworking equipment but also such items as garden tools, decorating material, and other apparatus commonly used by the practical man.

One of the most important considerations in planning a workshop is light, and this is where a home-constructed workshop scores against a ready-made one—the worker can arrange his windows where he wants them.

Lighting.—It is an advantage to have a number of windows running the whole length of the front of the workshop, where the workbench usually stands, while the inclusion of a skylight is one of those small items that make for comfortable working. If a skylight is included, a linen roller-blind should be fitted to eliminate the glare of the sun during the summer months.

Where possible, electricity should be used for the artificial lighting of the workshop, as it is safer and more efficient than gas or oil lamps.

In arranging the electric light points, do not forget to include a socket into which a portable light or any other useful portable electrical apparatus, such as a soldering-iron, can be plugged, and if a heating circuit is available a small portable heater will give additional comfort during cold weather.

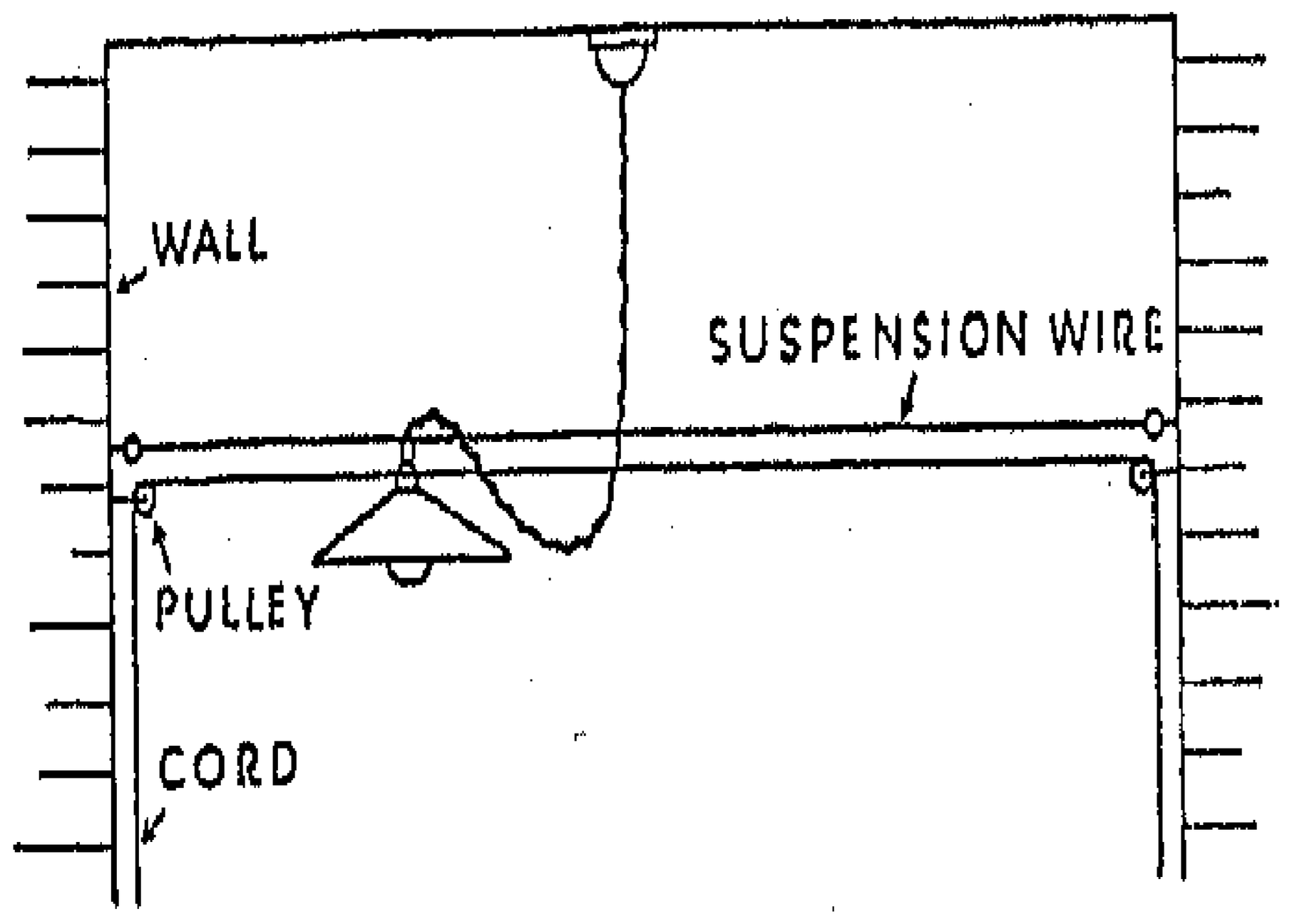


Fig. 1

The light over the bench should not be a fixture, but be capable of being shifted from one end of the bench to the other. This can be easily arranged by fixing the light to a cord running over two pulleys fixed to the walls, in the manner shown diagrammatically in Fig. 1.

The possible general arrangements of the workshop are so great that only a few practical suggestions can be made.

For instance, the workbench—especially the working-end of it where the bench-stop and vice are placed—should be directly in front of a window, so that no shadows are cast upon the work. Some workers use a fixed bench while others prefer a portable type.

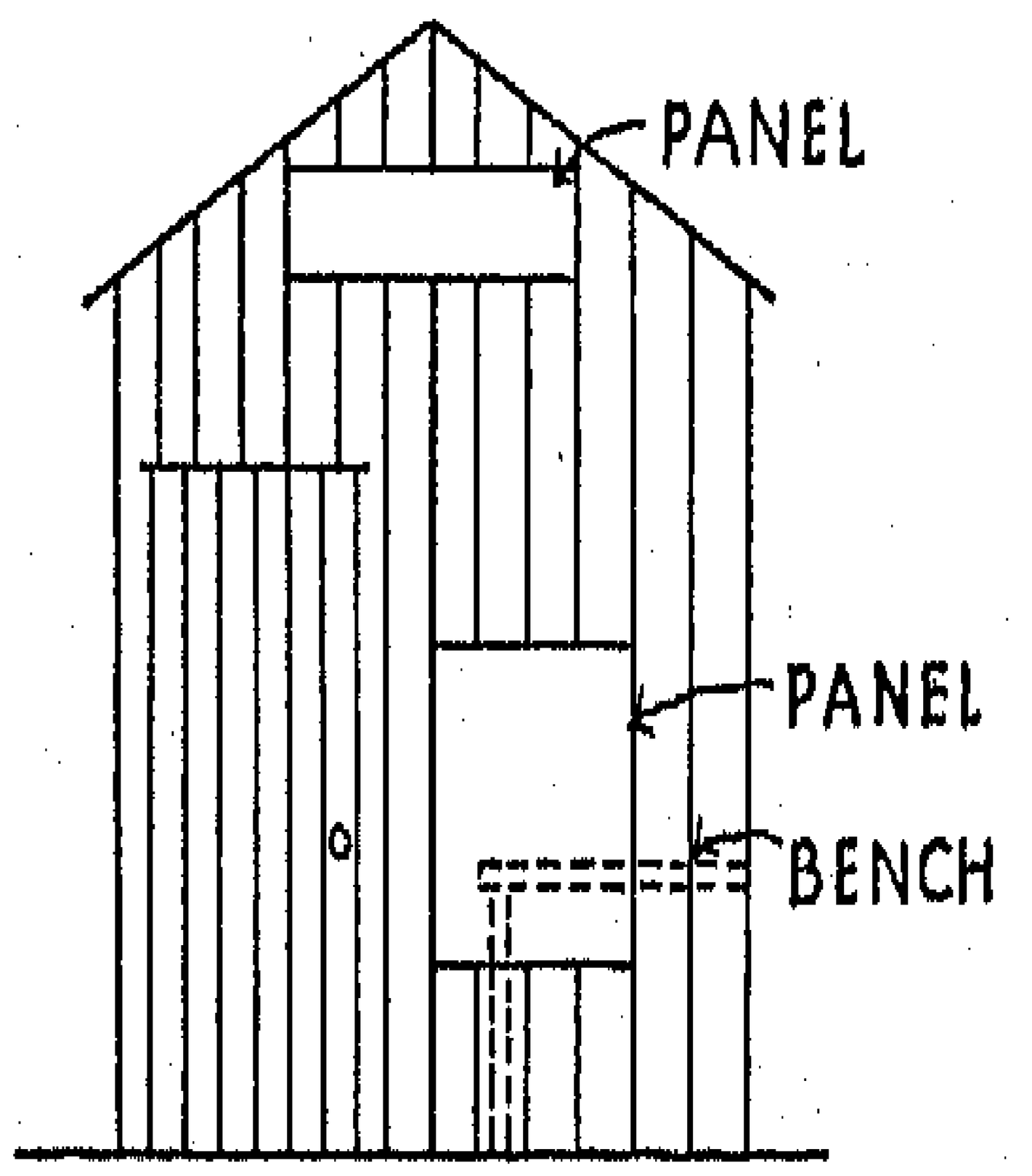
In some cases tools, such as chisels, files, bits, etc., can be kept in a rack at the back of the bench, but not at such a height as to interfere with the light from the window.

This arrangement may be quite satisfactory if no large work is intended, but it has the disadvantage that should at any time a fairly large door or frame be constructed, the rack would be obviously in the way, as the whole width of the bench is necessary for gluing, and planing after gluing.

Movable Wall Panels.—In cases where it is only possible to construct a small workshop, its capabilities can be greatly enhanced by making a movable panel in line with the bench-top, at each end, as shown in Fig. 2. This arrangement will be found of inestimable value when working upon long material, as the ends of the work can project beyond the ends of the workshop. Such panels can be easily arranged when constructing the framework. They can either be made to be entirely removed or hinged from the outside. If the use of loose panels is decided upon, they can be secured by turnbuttons operated from inside.

A similar movable panel could be arranged under a gable end of the roof to allow long lengths of timber to be easily inserted and stored upon a few pieces of scantling fixed across the workshop.

Fig. 2



Tools need arrangement. Saws, as a rule, as well as the saw-cramp, straight-edge, and similar tools, can be hung on nails driven into the walls, within easy reach of the bench.

Tool Racks and Shelves can be fastened to the walls at convenient points that will keep them out of the way yet leave them close to hand.

The racks can be made in various ways. Strips of wood, ½ in. thick and about 2 in. wide, cut out in the manner indicated at A in Fig. 3, and either nailed or screwed to a broader piece screwed to the wall between the uprights, make excellent racks for chisels, gouges, screwdrivers, etc.

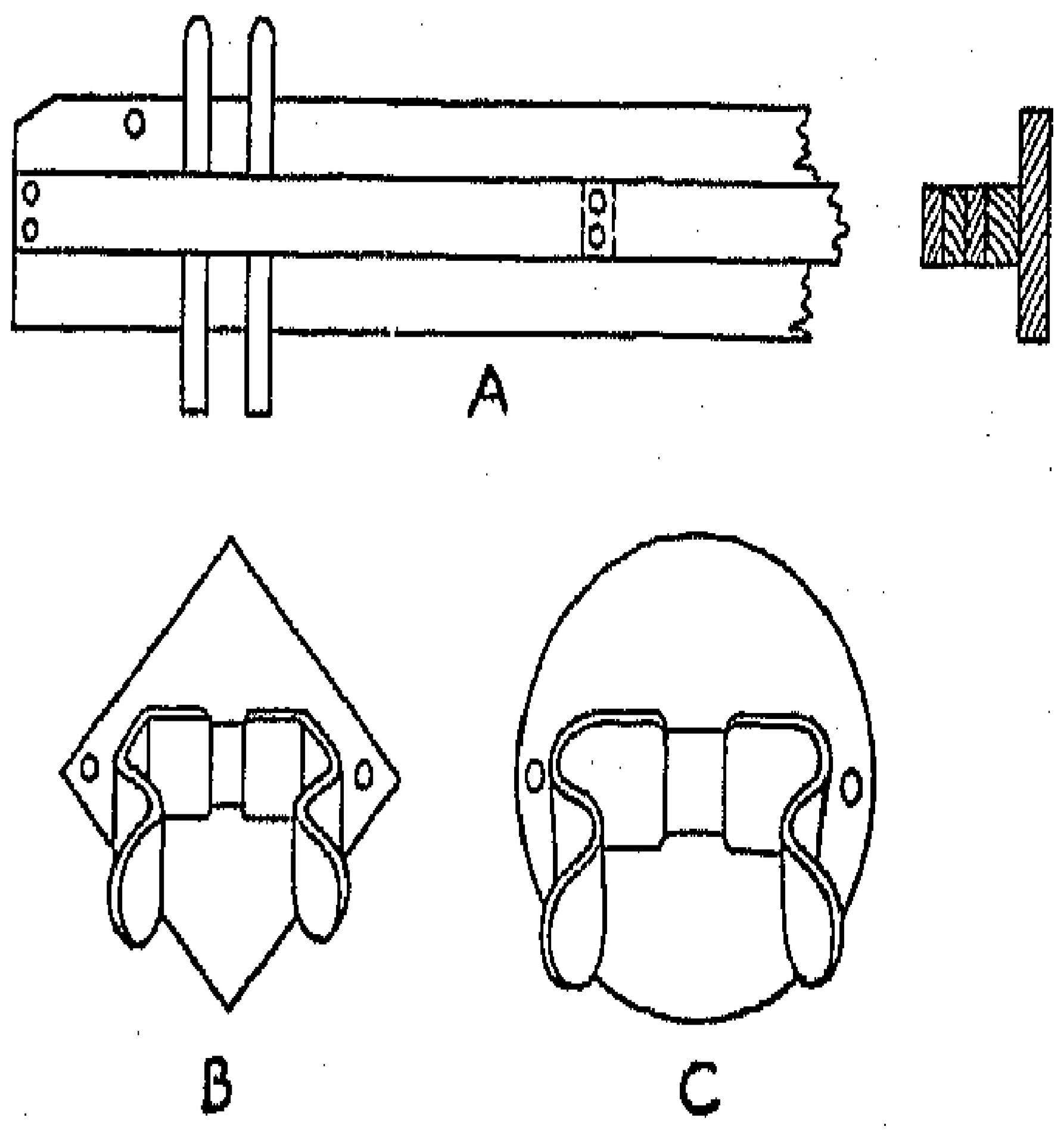


Fig. 3

Another serviceable type of tool rack can be made by screwing a number of spring clips of the types shown at B and C to a board about 6 in. wide, such clips being obtainable at most tool shops at a low cost. Where a rack of this type is employed, centre-bits can be kept in place by hanging them with their points upwards so that their shoulders keep them in the clips, and chisels, etc., with their handles up for the same reason.

If racks are used, they should be so arranged that others can be added if necessary, as your list of tools increases.

Small tools, such as twist-drills, should be kept in a block of hardwood, drilled with a sufficient number of holes to accommodate their shanks.

This method of storing drills is to be preferred to the unprofessional way of keeping them in a box, as it not only preserves the cutting-edges but also saves a considerable amount of time in selecting a drill of a particular size.

In preparing a block for twist drills, each hole should be bored with the same sized drill it is intended to accommodate, and the sizes should be plainly marked on the top of the block. An oak block about 3 in. long by 2 in. wide and 2 in. deep will hold over thirty small drills. A neat cover should be made to protect them from damp.

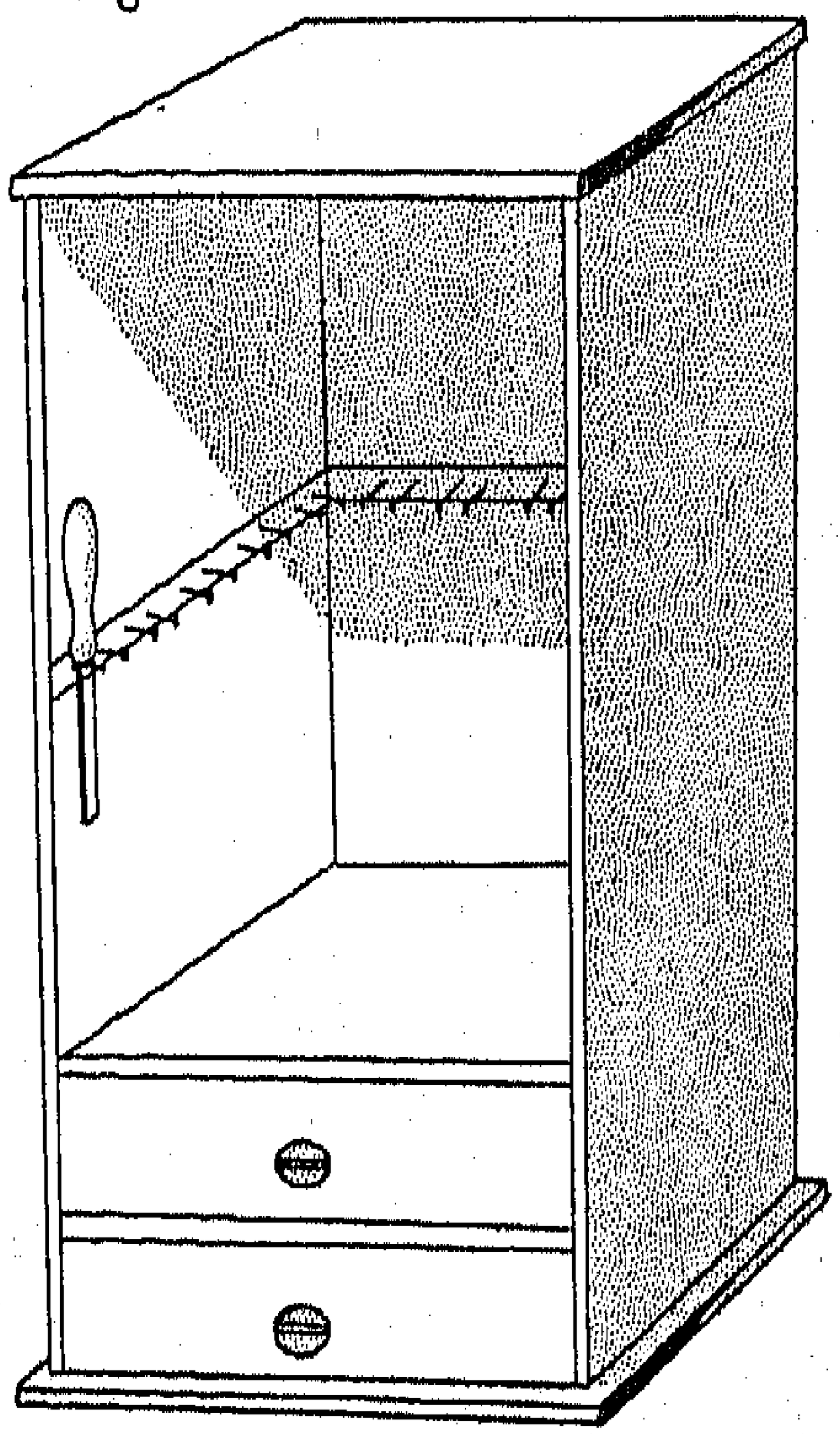
A Tool Cabinet.—Some workers may prefer to keep their tools in a cabinet or cupboard, in which case a receptacle made on similar lines to the one shown in Fig. 4 will be found to be serviceable and quite easy to construct.

The size of such a cabinet naturally depends upon the number of tools it is to contain and must therefore be left to the maker to decide.

The upper compartment contains a rack for chisels, etc., made by driving a series of nails or wooden pegs in the edge of a narrow support, as shown clearly in the drawing. The chisels lie between these projections and present a neat and orderly appearance. If wooden dowels are used, they should be sawn off so that they all project equally; and should nails be chosen, they should be driven in to an equal depth. To ensure this, a short piece of iron gas-pipe could be cut and placed over the head of the nail during the last stroke or two of the hammer, to act as a depth-gauge. This rack is, of course, made as a separate unit and fitted after the completion of the cabinet.

The top section also contains a shelf for the accommodation of planes, etc., while the lower compartment can either be fitted with shelves or drawers; or a piece of wood could be fixed to divide the section vertically, one side of which could contain shelves and the other be suitably fitted to accommodate saws, brace, etc.

Fig. 4



If desired, the top section can be fitted with a door or a flap hinged from the bottom rail and fastened at the top by means of a hook and eye.

After the cupboard is completed it should receive a coat of stain to enhance its appearance.

CONSTRUCTIONAL WOODWORK

A WORK BENCH

A work bench should be rigid, without spring, and not too heavy to enable it to be comfortably moved about from place to place, yet heavy enough to prevent it from shifting from its position when in use.

The bench described in the following paragraphs fulfils these conditions, and as it is cheap and easy to construct it should appeal to those readers whose pockets are not too "well lined" and whose knowledge of woodwork is limited.

A general idea of the bench may be obtained by referring to the drawings in Working Drawing No. 1.

It will be seen that the space beneath the bench-top is made use of by the provision of two shelves for holding tools, etc., a feature not generally found in the ordinary type of carpenter's bench. This space is totally enclosed by means of three plywood panels, $\frac{1}{8}$ in. thick, fitted to the sides and back, and hinged doors at the front. This useful feature is optional and can be omitted if desired without interfering with the strength and general usefulness of the structure. Where possible it should be included, as the small amount of extra labour involved in its construction and the trifling additional cost will be well repaid by being able to keep your tools under lock and key. The overall dimensions of the bench are 4 ft. 6 in. in length, 2 ft. 2 in. wide and 2 ft. 9 in. high—a convenient size for general purposes.

One of the most important items in connection with a woodworking bench is the provision of suitable devices for holding the work. A useful type of vice suitable for use with a bench of this type can be either one of those handy metal tools which screw down to the top of the bench by means of four screws—as shown in the accompanying illustration in Fig. 1—or it can be one of the wooden variety having two adjusting screws and fixed to the front of the bench by means of two or three iron screws. Such a vice is shown in Fig. 2. The former costs about 7/6, while the latter is listed at about 3/-.

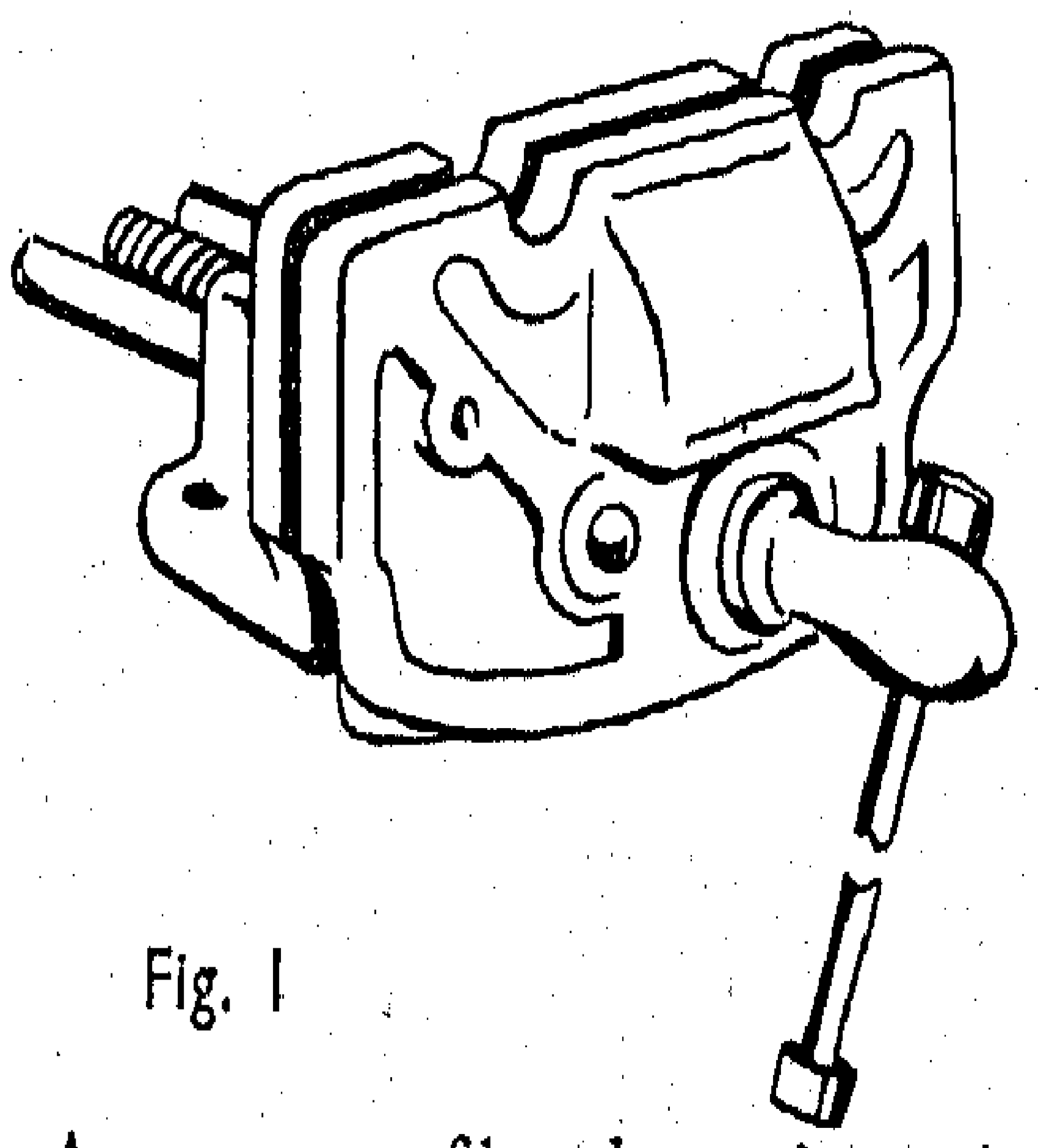


Fig. 1

As some sort of bench stop is required when planing the faces of boards, etc., an adjustable metal stop (Fig. 3), costing about eighteenpence, is an excellent one to have, and is much to be preferred to the old-fashioned stop consisting of a rectangular block of wood driven tightly into a hole in the bench-top. The metal stop is adjusted by means of a screw which raises or lowers the lip to the desired height and also allows it to lie flush with the top surface of the bench when not in use.

The following is a list of the finished sizes of the parts:

Description	*No.*	*ft.*	*in.*	*ft.*	*in.*	*in.*
Legs	4	2	7 ×		3 ×	3
End cross-pieces	4	2	0 ×		3 ×	2
Top front rail	1	4	6 ×		6 ×	1
Bottom front rail	1	4	0 ×		3 ×	2
Top back rail	1	4	6 ×		8 ×	1
Bottom back rail	1	4	0 ×		3 ×	2
Bench-top boards	2	4	6 ×		9 ×	2
Bench-top (middle)	1	4	6 ×		7 ×	1
Struts	2	3	0 ×		2 ×	1
2 shelves and bottom boards	7 (approx.)	2	0 ×		8 ×	¾
Door stiles	4	1	10 ×		1¾ ×	¾
Door rails	4	1	8½ ×		1¾ ×	¾
Side panels	2	2	4 ×	2	0 ×	⅛
Back panel	1	4	0 ×	2	4 ×	⅛
Bearers	6	2	0 ×		2 ×	¾

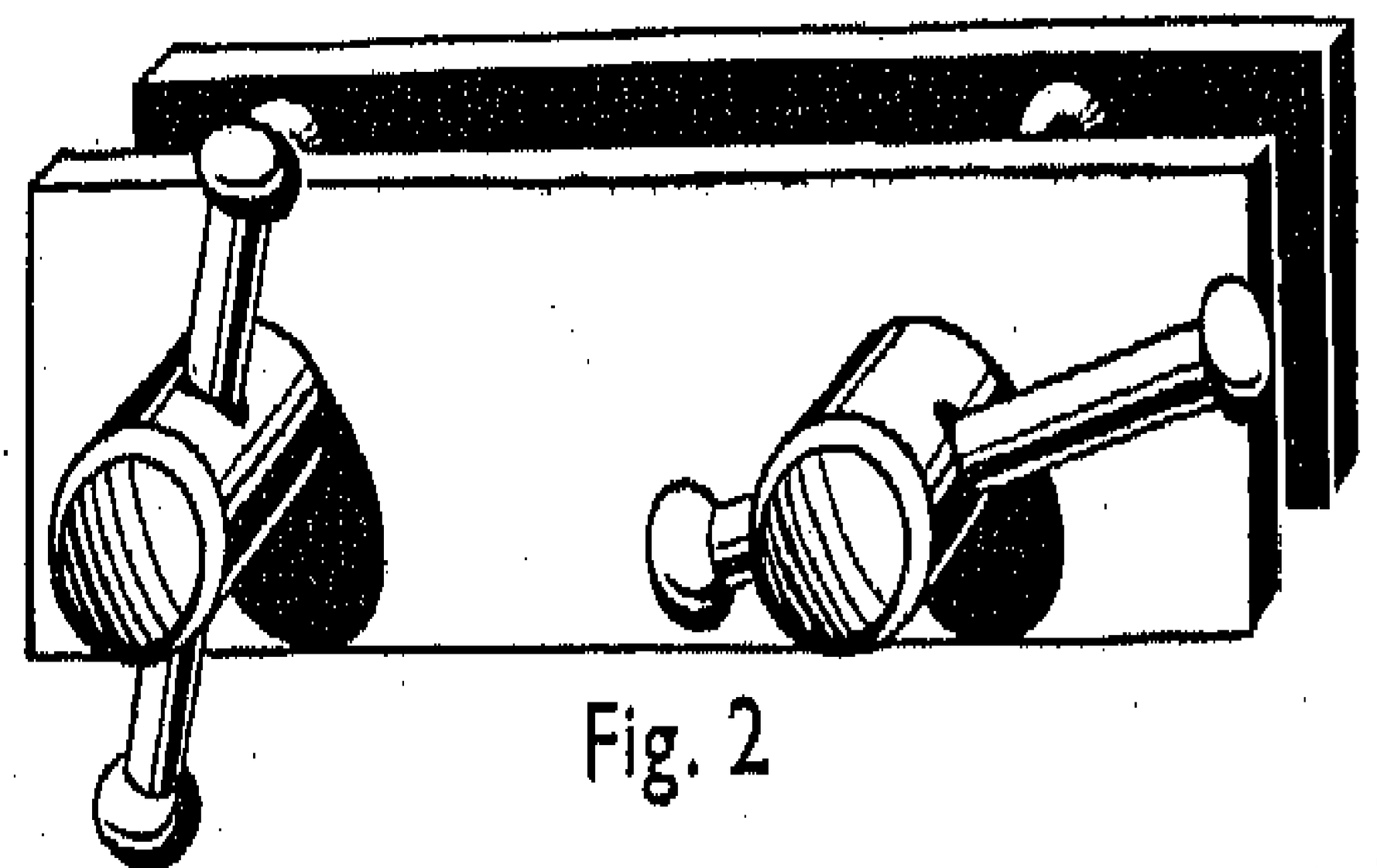


Fig. 2

The bench should be constructed of good quality yellow joinery deal, perfectly straight and free from knots and shakes. It is a good plan to purchase the timber ready planed and cut roughly to size, as the small extra cost over the unprepared stuff is more than compensated for by the great saving of time and labour.

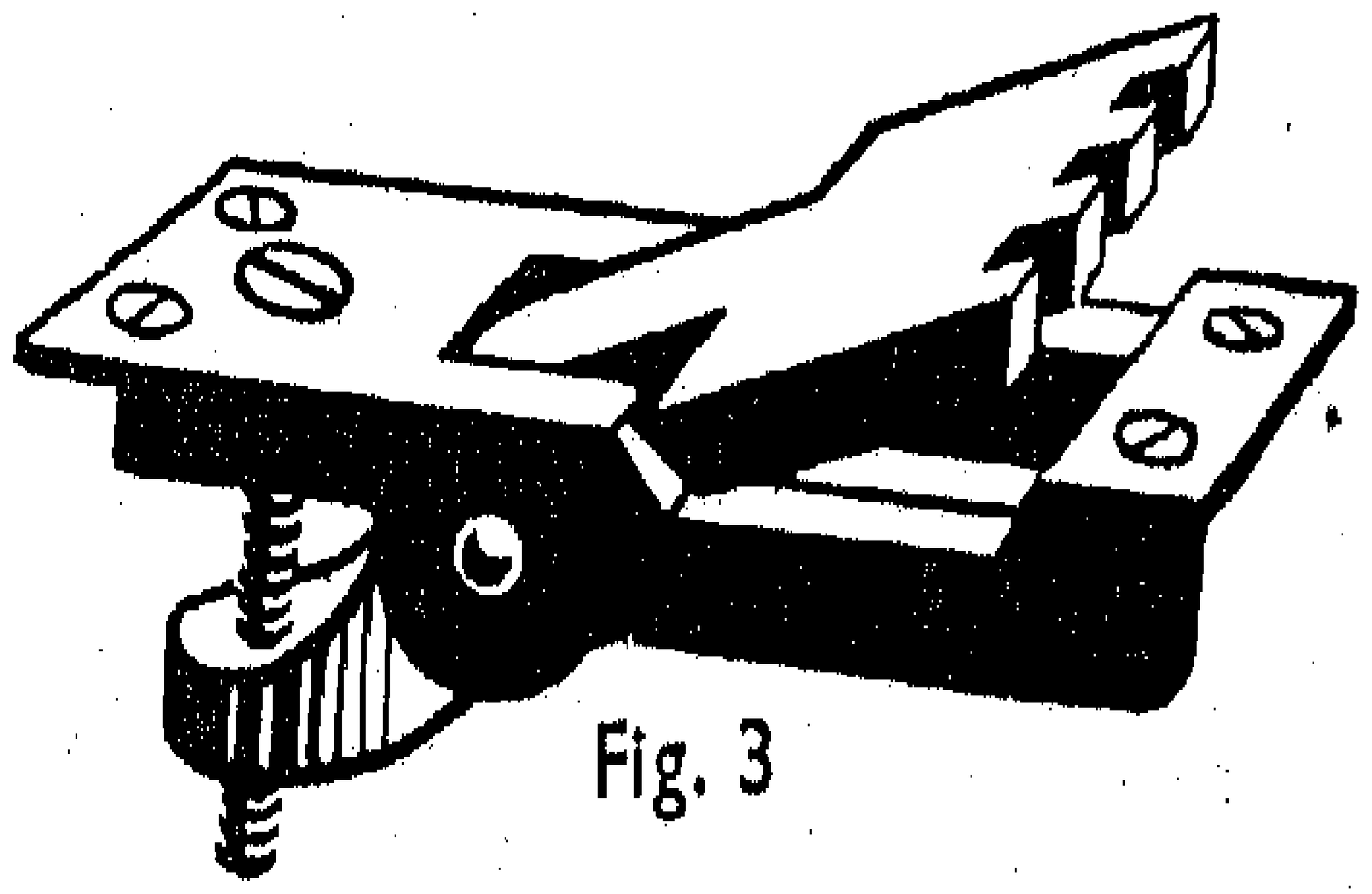


Fig. 3

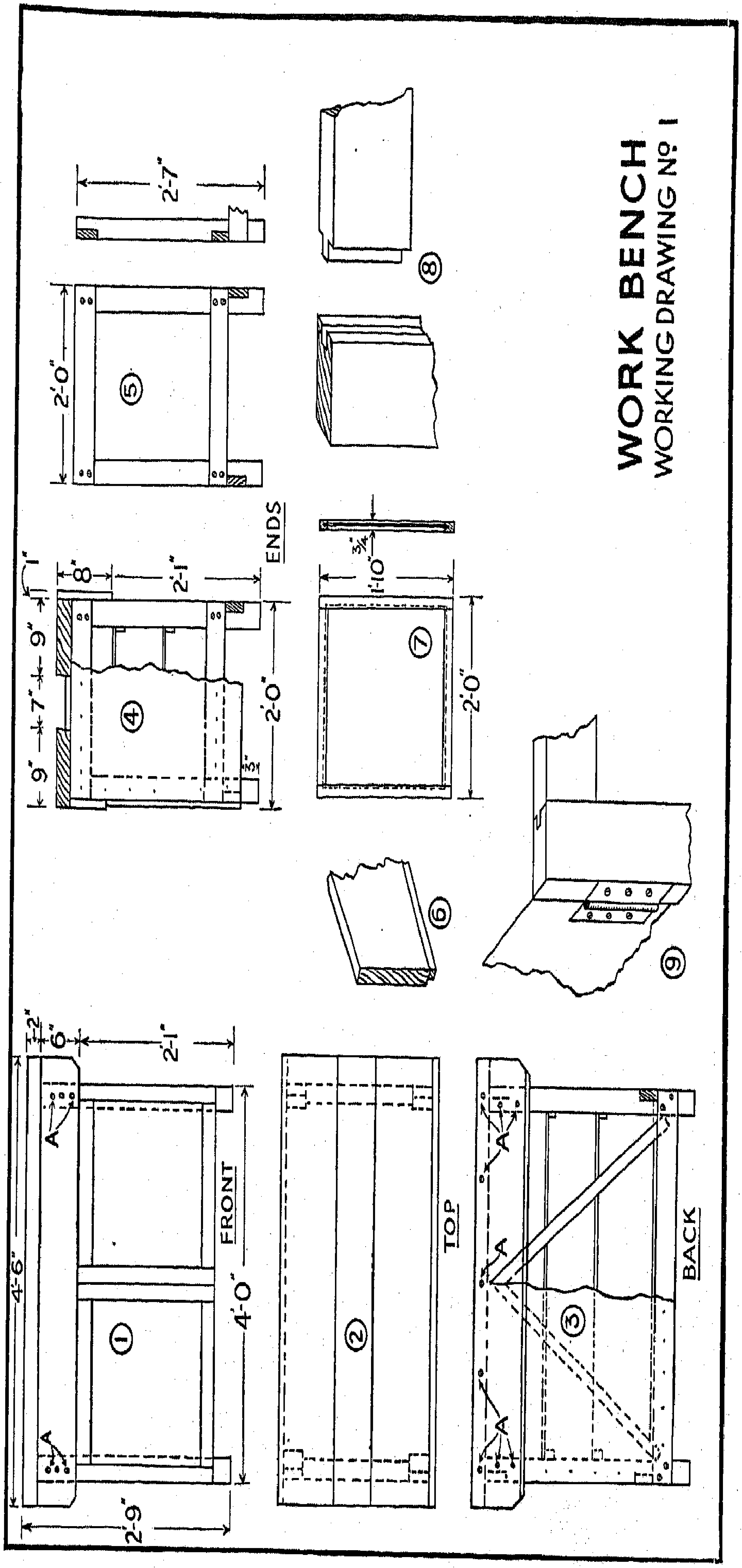
Prepare the two end frames, as shown in Fig. 5 in the Working Drawing. Two end frames are required, one for the right hand and one for the left.

Each frame consists of two legs 2 ft. 7 in. long of 3 in. by 3 in. deal, and two cross-pieces each 2 ft. in length, 3 in. wide and 2 in. thick. The top rail is fixed flush with the tops of the legs, while the bottom one is placed with its lower edge 6 in. above the floor level. The joints used are halved joints—one of the simplest joints it is possible to make.

Mark out the positions on the legs where the joints are to be and remove the waste with the aid of a tenon-saw and chisel, taking care to make every saw-cut on the waste side of the line.

Having prepared all the joints, the members can be fixed together by using 2½ in. No. 12 countersunk iron screws or, if preferred, by using glue and dowel-pins. In both methods it is advisable to draw the parts together tightly by means of a cramp before inserting the screws or the dowels.

Halve the ends of the two lower long rails which join the end frames at the bottoms of the legs. The corresponding top rails are formed of planed boards 1 in. thick, the front one being 6 in. wide and the back one 8 in.



Nail a strip of ¾-in. square wood along the bottom edge of the top back rail to form a rebate a trifle over ⅛ in. wide to take the top of the plywood panel, as shown in Fig. 6. Mark the positions of the fixing screws on the top rails, as shown at A in Figs. 1 and 3, and then drill holes a trifle larger than the diameter of the screws at these positions. Countersink the tops of the holes to allow the screw-heads to lie just below the surface. Mark and drill the bottom rails in the same manner. The position for these screw-holes is 2 in. from the ends.

Assembling the Framework.—The next process consists in assembling the framework. A convenient way to do this, if an assistant is not available, is to place the end frames with the back faces of the rear legs resting on the floor and the top rails against a wall. Place the top front rail in position and drive a screw partially into the left-hand leg; repeat the process at the other end, which will enable the framework to stand up without support. Now fix the bottom rail. When you have satisfied yourself that the work is perfectly square by verifying it with a large try-square, tighten up the screws already in and drive in the remaining ones.

Turn the frame over so that the back is now uppermost and proceed by fixing the back rails, bearing in mind that the top rail projects 2 in. above the end frames.

The next step consists in fitting the back struts, so the framework can now stand in its normal position, that is, of course, with the feet on the floor. Mark and cut the struts, which are made of planed batten 2 in. wide by ¾ in. thick, and fix them by means of screws in the positions shown in Fig. 3.

Now mark the positions and bore the screw-holes in the thick top board in a manner similar to that described for the long top rails. When making the holes near the front edges, take particular care to keep the bit vertical, otherwise the screws may miss the comparatively narrow edge of the rail.

Screw the front and back top boards down to the framework and then fix the middle one, the latter being held down with 1½-in. No. 8 screws.

The main portion of the job is now complete, and if the work has been carefully done the structure should be perfectly stable and rigid. Make sure that the bottoms of the legs all stand perfectly level on the floor; if such is not the case now is the time to make adjustments.

Fit the bottom boards and the shelves. For supporting these, six pieces of 2-in. by 1-in. batten are required for bearers, which are fixed across the inside faces of the end frames. The bearers for supporting the bottom boards should be fixed so that their upper edges are flush with the tops of the long bottom rails. The supports can be fixed either with nails or screws.

Mark and cut the three bottom boards so that they are a nice fit between the bottom rails of the end frames, not forgetting to make the recesses to clear the corners of the legs and the struts.

The shelf supports, or bearers, and the shelves, which are 16 in. wide, are fixed in a similar manner in positions to suit the requirements of the user.

The Plywood Panels are quite simple to fix and no difficulty should be experienced from this source. They should be fastened to the frames by means of ¾-in. thin round brads driven in at intervals of about 6 in. The back panel is fitted by first sliding the top into the rebate or groove formed between the ¾ in. thick strip of wood on the bottom edge of the back board and the struts and legs. The top of the panel is fixed from the inside by driving brads through the panel into the wooden strip, the bottom and sides being "pinned" from the outside.

The bench stop should be fitted at about 6 in. from the left-hand end and in the centre of the first top board. Mark out the position for this and make the recess by first partially removing the waste with the aid of a brace and bit and then trimming up the edges with a sharp chisel.

Having fitted the vice, the bench may be put into commission, as it will be useful when constructing the doors.

Those readers who do not wish to go to the trouble of making panelled doors can use solid ones cut accurately to size from ½ in. thick plywood. Plain plywood doors, however, do not have a particularly pleasing appearance, and as panelled doors are very simple to construct, the little extra time needed for their construction is not time wasted.

The framework of the panelled doors can be built up from standard-size plain hardwood moulding, having a groove already formed in one narrow edge for taking the panel. This handy material is quite inexpensive and can be purchased at most shops that cater for amateur woodworkers' requirements. For the two doors, two 8 ft. lengths of 1¾-in. by ¾-in. plain grooved moulding will be required.

Fig. 7 in the working drawing shows a detailed illustration of the method of construction of a door. First cut the stiles or vertical pieces, which should be 2 ft. in length—1 in. longer at each end than the finished size is to be. Next prepare the rails or cross-pieces. The overall length of these is 22 in., which allows ¼ in. at each end for forming the short strut tenons that fit into the grooves in the struts, as shown in Fig. 8.

Having cut the tenons, the parts can be assembled by first gluing the joints and then the edges of the panel, inserting the panel and keeping them together with the aid of cramps or wedges until the glue has set perfectly hard. The ends of the stiles are then carefully sawn off and, if necessary, the whole of the frame trimmed up with a very sharp, finely-set plane.

The Hinges.—Fix these as shown in Fig. 9. To prevent the doors being forced inwards and thus straining the hinges, a strip of wood should be screwed to the inner face of the top rail, allowing an inch to project below the bottom edge of the rail. A similar piece of wood screwed to the bottom board will answer the same purpose at the bottom. A couple of small sliding bolts fitted on the inside face of one of the middle stiles and a small lock fixed on the other, completes the work.

THE HOME WORKSHOP

THE workshop or garden shed, shown in the accompanying illustration (Fig. 1) and the Working Drawings Nos. 2 and 3, has been designed with the object of simplifying the construction to enable the man who can use a few carpenter's tools to erect it without difficulty. Such a workshop will last a lifetime, provided it is given a yearly coat of paint or creosote.

If the drawings are studied carefully, it will be seen that the structure is built in sections, a feature which enables it to be easily dismantled and re-erected.

Before starting the actual construction, a suitable site should be decided upon, bearing in mind that a dry position is essential and that the best situation is one that faces south, or south-west. A northern aspect is likely to be dark and depressing. It is a good plan to prepare the site before accepting delivery of the materials for, by so doing, the constructional work can then be proceeded with without delay.

If the site chosen is covered with grass, the turf should be removed, the ground made as level as possible and well rammed down.

Foundation.—An excellent foundation for a structure of this description can be made by using three disused railway sleepers, which can usually be obtained from the railway company for a few shillings. This method keeps the structure dry, well off the ground.

The use of railway sleepers is an improvement on the usual method of laying a few bricks on their large faces flat on the ground and spaced at intervals under long floor supports or "sleepers," as they are called. Bricks, owing to their comparatively small area, are liable to sink into the ground in the course of time and consequently upset the level and squareness of the building. If they have to be used, they should be placed transversely under the horizontal members supporting the floor joists, spaced at distances of not less than 2 ft. apart.

Tools required for carrying out the work include a good, sharp handsaw, tenon-saw, 1-in. chisel, try-square, bevel, bradawl, brace and bits, straightedge and a rule.

Before ordering the timber it is a good plan to study the list of sizes to enable you roughly to estimate the number of particular lengths required, as this will avoid a good deal of waste. If the material for the framework, let us say, is specified as so many feet of scantling, the timber-merchant will probably send odd lengths. For example, by referring to the following list you will see that six 7-ft.-long floor joists are required. This item should be ordered as three 14-ft. lengths, which will cut two joists out of each without waste.

The following is a list of the approximate sizes of the timbers, to which should be added at least 10 per cent. for waste.

Parts	*No.*	*Size* *ft.*	*in.*	*in.*	*in.*
FLOOR:					
Sleepers, or joist plates	4	10	0	3	2
Joists	6	7	0	3	2
Flooring	70 sq. ft.	6 in. × ⅞ in. tongued and grooved flooring.			
FRONT:					
Top and bottom plates	2	10	0	2	2
Studs	4	5	9	2	2
Cross-pieces	2	3	0	2	2
Top of window	1	3	6	2	2
Bottom of window	1	3	7	2	2
BACK:					
Top and bottom plates	2	10	0	2	2
Studs	4	5	9	2	2
Cross-pieces	3	3	2½	2	2
END:					
Centre stud	1	7	9½	2	2
End studs	2	5	6½	2	2
Bottom plate	1	6	8	2	2
Roof-pieces	2	4	0	2	2
Top cross-pieces	2	3	3½	2	2
Cross-pieces	2	3	2	2	2
DOOR END:					
Door studs	2	6	9	2	2
End studs	2	5	6½	2	2
Roof-pieces	2	4	0	2	2
Bottom plate	1	6	8	2	2
Top cross-pieces	2	1	10	2	2
Cross-pieces	2	1	8½	2	2
Cross-piece top of door	1	2	10	2	2
ROOF:					
Purlins	4	10	4¾	3	2
Capping-pieces for ridge	2	10	6	6	⅝
Gable ends	4	5	0	6	⅝
Battens	10	4	6	2	¾
WINDOW:					
Lining, horizontal	1	3	6	2	½
Lining, vertical	2	1	9½	2	½
Sill	1	3	10	4	2
Stiles	4	1	9½	2	1¼
Rails	4	1	8½	2	1½
Stops, horizontal	2	3	5	¾	½
Stops, vertical	2	1	9½	¾	½
DOOR:					
Ledges	2	2	7	6	⅞
Brace	1	5	2	4	⅞

Allowing for waste, this gives the following approximate quantities: 125 ft. of 3 in. by 2 in. scantling; 325 ft. of 2 in. by 2 in.; 2½ squares of matching for the front, back and ends; 80 sq. ft. for floorboards and 110 sq. ft. matching for the roof.

The following miscellaneous items will also be required. One pair of 14-in. cross garnets for hanging the door; two pairs of iron butt hinges for windows; one rim lock for the door; quantity of 2-in. and 1½-in. cut nails; 3½-in. and 4-in. wire nails; ½-in. galvanised clout nails for fixing roofing felt; 1½-in. galvanised wire nails for fastening roofing battens; eight 6-in. by ⅜-in. iron bolts, nuts and washers; creosote and roofing felt.

When the material is delivered it should be placed under cover to keep it perfectly dry or, if this is impracticable, the timber should be stacked on cross-pieces or odd wood and covered over with sacking or sheets of galvanised iron. Otherwise you may have difficulties not only in cutting but also when fitting the tongues and grooves in the matching.

The Floor.—When the material is to hand and the site and foundation have been prepared, a start may be made with the construction of the floor, as the walls stand on the edges of this.

Prepare the three long sleepers and floor joists by first marking and then cutting them to their correct lengths.

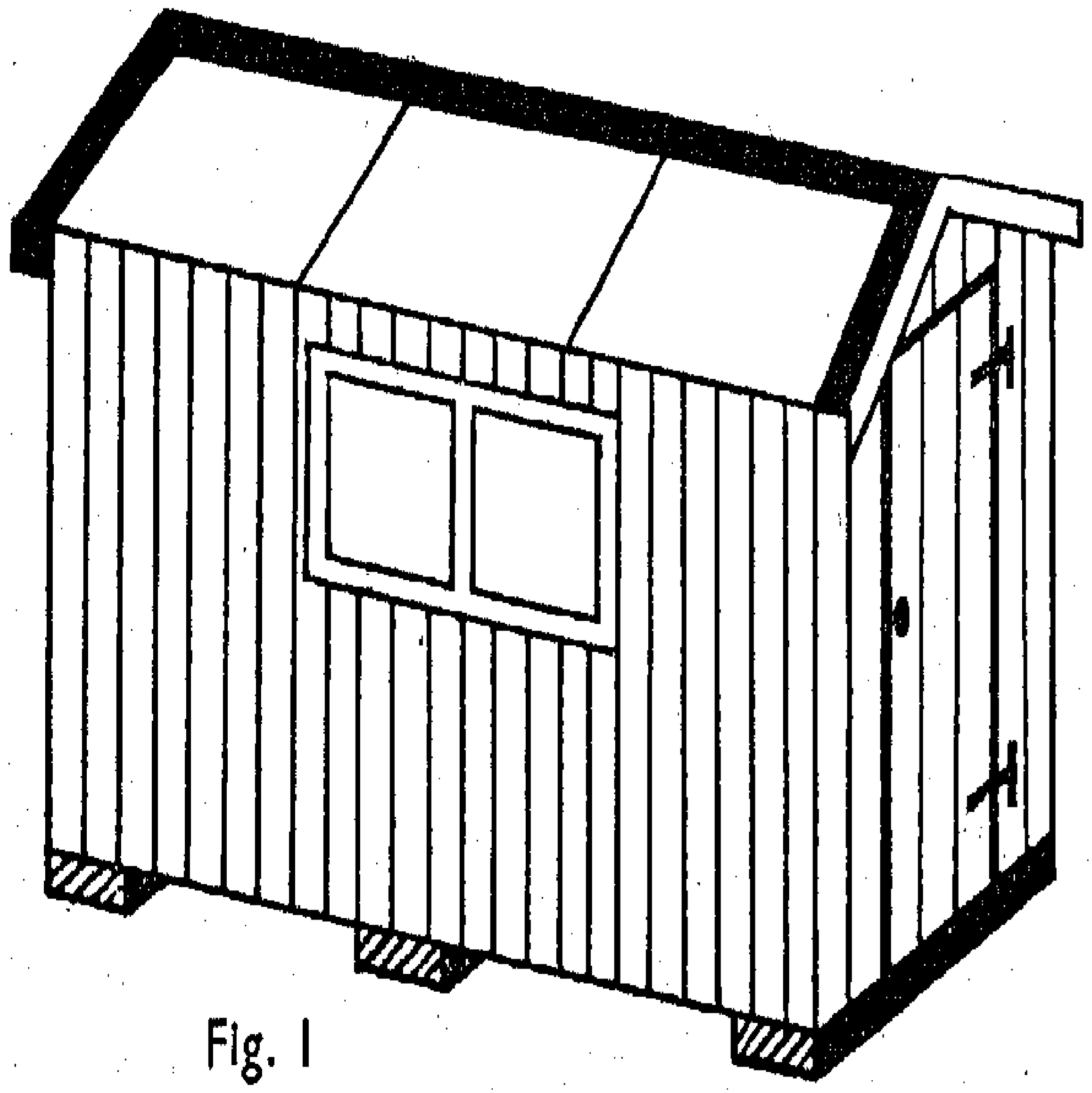


Fig. 1

Give them a good coat of creosote and place the bottom members across the railway sleepers, making sure that they are at the correct distances apart and are perfectly level. To keep these in position for the time being, drive a nail obliquely through the members at each point of contact as shown in the elevation of the floor. Do not drive them right home as they have to be withdrawn after the joists have been laid.

Next mark out the positions for the joists on the two outer supports. Reference to the drawing will show you that the positions for these are 2 ft. apart. Fix the two end joists first, and then follow with the others. As these are fixed down with 4-in. wire nails which are of a somewhat heavy gauge, it is advisable to bore holes for their reception by using a brace and shell-bit of small diameter.

The framework of the floor is now complete. It should be squared up and tested to see that it is perfectly level. The long bottom members should bear upon the railway sleepers at every point of support. If such is not the case, slips of wood should be inserted between them for this purpose.

The next procedure consists in cutting and laying the floorboards. If it has not been possible to obtain these in 10- or 20-ft. lengths, as previously suggested, the boards should be cut to such a size as to avoid any unnecessary waste. For instance, if the boards are supplied in 15-ft. lengths, a lot of waste would be avoided by putting in an extra joist in the middle of the floor frame to support the ends of the two half-lengths. In this case first nail a full-length board flush with the ends of the joists at either the back or the front, and then proceed by fixing another long board followed by two short ones, and so on until the whole of the joists are covered.

Before laying the first board, however, it is necessary to remove the tongue so that a plain edge is flush with the ends of the joists. This enables the tongue of the next board to be inserted into the groove of the first, which is much easier to accomplish than fitting them vice versa.

Fasten the first board down by driving in 2-in. cut nails at a distance of 1 in. away from the long edges, taking care to see that they are driven into the centres of the joists. Insert the tongue of the second board into the groove of the first and nail this down at the back edges only and proceed in a like manner until all the floorboards are in position. The remainder of the nails can then be driven in the front edges to complete.

If you experience any difficulty in fitting the tongues into the grooves, do not be tempted to hammer them in without first inserting an odd piece of tongued board to take the blows; otherwise the groove will be badly bruised and cause further difficulty when the following board is to be fitted.

Another important point to observe is that the edges of the boards must fit tightly against their fellow-members.

It sometimes happens that a board is not quite straight, in which case it can be forced into position by first inserting the tongue into the groove at one end, nailing it down, and then driving a chisel into the joist at the other end and prising the board into position, not forgetting to interpose the wooden block to prevent damage to the edges.

The floor is complete when any ends of the boards projecting over the end joists have been trimmed off flush.

The Construction of the Framework may now be put in hand. By referring to the drawings it will be seen that the top plates of the front and back are notched to house the ends of the vertical timbers. The notches are 2 in. wide and cut ½ in. deep.

When the positions of the notches have been marked, the surplus material is removed with the aid of a tenon-saw and chisel.

Start with the front, the assembly of which is quite straightforward and should therefore present no difficulty. The members are simply fixed together by means of 3½-in. wire nails. Like the floor joists, the members should be drilled to take the nails to prevent splitting the wood.

The back section calls for little comment as the construction is similar to that of the front. The nails for fixing the inner ends of the horizontal members to the uprights or "studs" should be driven in obliquely.

With regard to the end frames, it will be noticed that the top horizontal members are not notched at their outer ends but are merely nailed with 4-in. nails on top of the outer uprights, while the sloping pieces forming the roof supports are nailed to the horizontals.

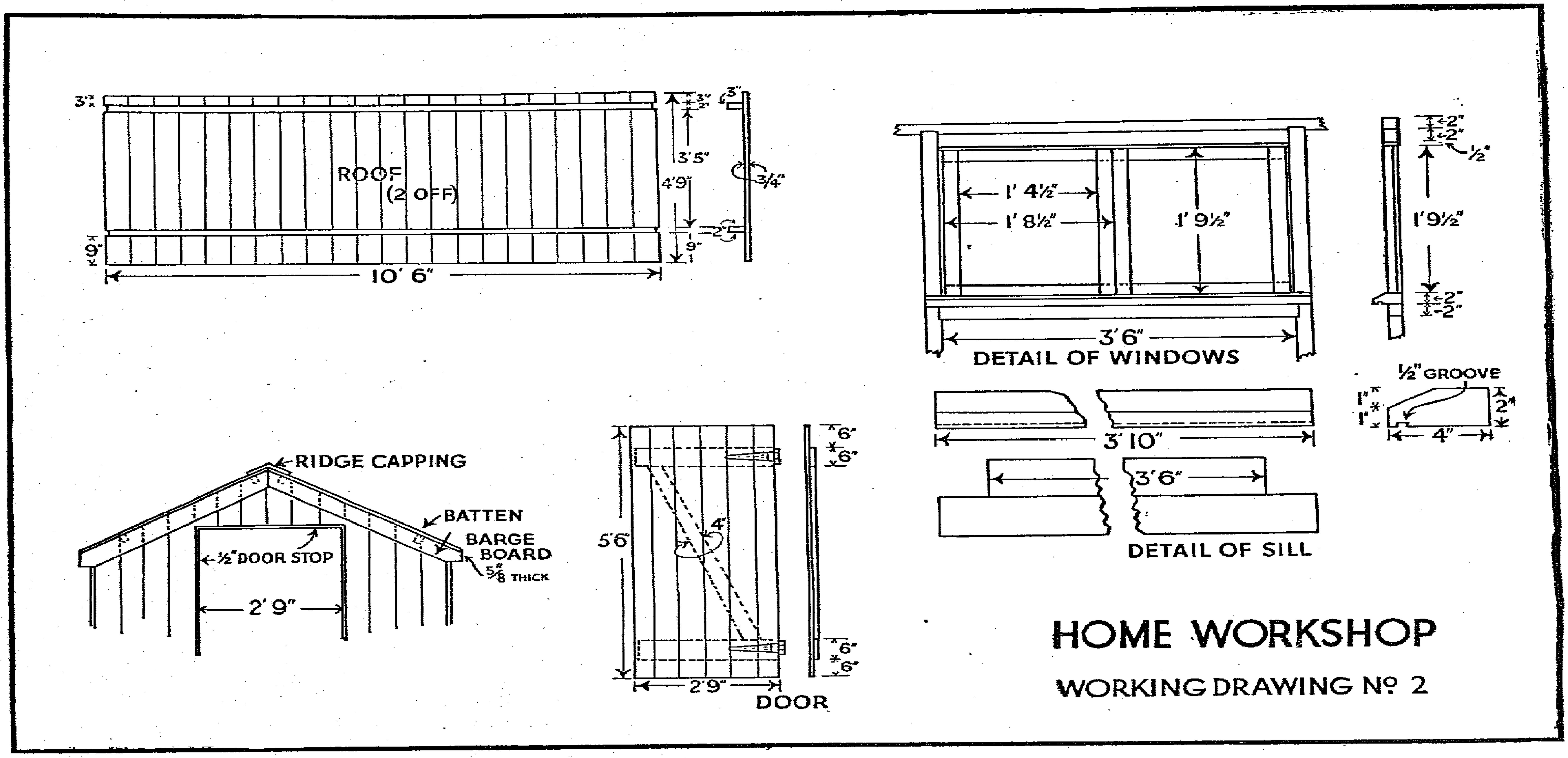
The best way to deal with the roof supports is first to mark them at the ridge and eave ends to the correct angles, using a bevel for the purpose.

Details of the construction of the roof are shown in Working Drawing No. 3. Two roof sections will be required. Each section consists of ¾-in. tongued and grooved matching fastened down to two 3-in. by 2-in. horizontal members called "purlins."

The Roof Sections.—First cut the purlins to a length of 10 ft. 6 in. and the boards to 4 ft. 11 in., which allows an inch extra for waste at the ends. Nail the boards down so that their top edges project 3 in. from the outer face of the top purlin and 9 in. from the bottom one. When the boards have been nailed down, mark a line across them from one end to the other at the correct distance from the purlins, and remove the waste with a hand-saw. This method is to be preferred to cutting the boards to their correct lengths and then nailing them down to the members, as it ensures even and parallel edges.

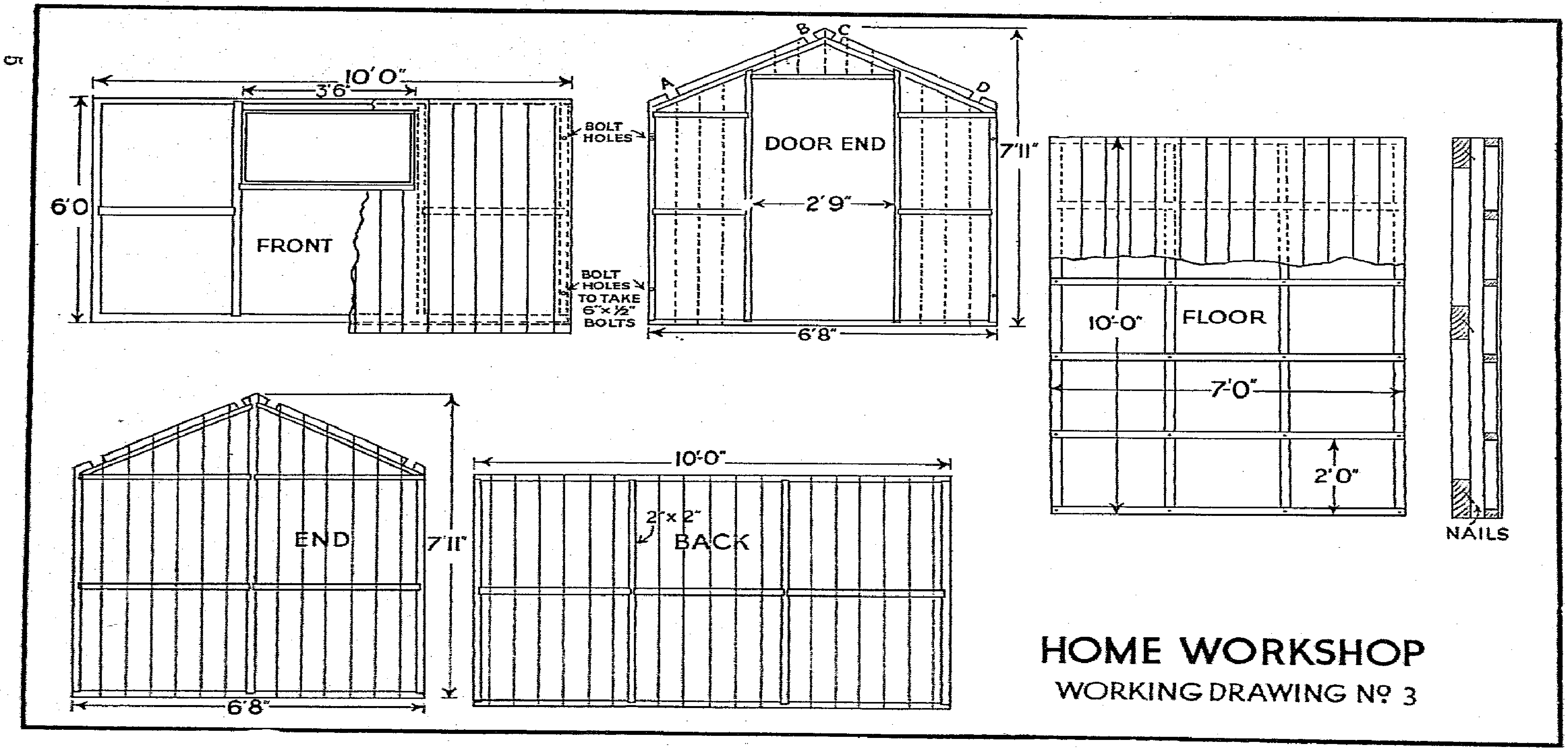
Having completed the boarding, cut ⅝ in. off the ends of the purlins to allow the barge boards to be fixed flush with the ends of the roof as indicated in the detail of the roof.

Before proceeding any further with the constructional work, it is advisable to give the exterior of the roof a good coat of creosote, and when sufficient time has elapsed to allow it to dry—this



HOME WORKSHOP

WORKING DRAWING Nº 2



HOME WORKSHOP

WORKING DRAWING Nº 3

does not take long—to cover it with roofing felt.

Although some workers prefer to fix the roofing felt after the roof is in situ, it will be found easier to carry out the work on the level.

Covering the Roof.—The simplest and cheapest way is to use one of the many excellent proprietary brands of roof covering, which must not be confused with the old-fashioned tarred felt. It is sold in rolls 1 yd. wide, 36 ft. long. For covering the roof, two strips 11 ft. in length will be required for each section, which allows sufficient material for lapping the joint and for turning over the lower edges. Unroll the felt on a flat surface, taking care not to tear or otherwise damage it, and cut it to the required lengths by using a sharp knife and straight-edge. To lay the material, start at the top edge of the section and fasten it down with ½-in. galvanised clout nails spaced at 2-in. intervals, taking care to see that it lies perfectly flat. Nail the second piece down after allowing the bottom edge of the first strip to overlap the second by 4 in. Bend the felt over the bottom edges of the roof timbers and nail it down to the bottom face. Now carefully cut the material to remove the surplus, after allowing a couple of inches for turning under.

The frames of the four sections may now be covered with matching, but before actually starting on the job it is absolutely necessary to see that all sections are perfectly square. This should be carefully checked and if any one is found to be incorrect, it should now receive attention. To keep the sections perfectly square it is a good plan to nail one or two strips of wood across the members at the angles.

The Matching is fixed in exactly the same manner as that described for the floor. Note that the first and last boards on the front and back sections overlap the frame ends by ⅝ in. to cover the edges of the boards of the end sections. When cutting the boards to length do not forget that the bottom edges overlap the plates by 3¾ in. to cover the ends of the floor and joists.

The matched boards of the end sections project 3 in. above the tops of the sloping roof pieces. Fix the boards as shown in the drawings of the end and door end in Working Drawing No. 2, and then mark and cut off the waste after nailing them in position.

Having completed the boarding, cut the slots at the top of each end section in positions shown at A, B, C and D. The size of these is 2 in. wide by 3 in. deep. These recesses provide a simple and effective means of supporting the ends of the roof purlins, and keep the roof in position.

Now drill the bolt holes in the corner posts in the positions shown in the drawing of the front, using a ½-in. twist-bit for the purpose.

Assembling the Sections.—The next step is to assemble the sections. If possible, get a friend to give you a hand with this.

Place the front section in position and see that the bottom plate rests flush with the sides of the floor. Your helper will now hold this in position whilst you place the plain end section in position. Having done this, insert the two bolts, not forgetting to fit the washers before fastening the nuts. Tighten up the nuts finger tight. The two parts will now be self-supporting. Place the door end in position and then the back, insert the bolts, and screw all the nuts up tightly with a spanner.

Next put the roof in position by inserting the purlins into the respective slots at the top of the end sections, taking care to see that the ends of the roof overlap the walls equally.

Mark and cut the barge boards as shown in Working Drawing No. 2, then fix them to the ends of the roof by driving nails through them into the ends of the purlins, and also by a few nails driven in from the top edges of the roof.

When the roof capping, consisting of two 6-in.-wide boards, has been fixed, the roofing battens can be cut to length, creosoted and screwed down with 1-in. No. 6 screws.

The Door is of the ordinary ledged and braced type, dimensions of which can be readily taken from the details shown. The ledges should not be flush with the long edges of the door but cut back ¾ in. to allow the door to close when the door stopping is in position.

An ordinary iron lock—which is not an expensive item—should be fitted on the inside of the door at a height of about 3 ft.

Hang the door with a pair of 14-in. cross garnet hinges, and then fit the door stopping on the inner face of the frame.

The final constructional step consists in making the window and frames.

The Window Sill is formed from a piece of timber 3 ft. 10 in. long, 4 in. wide and 2 in. thick. Mark this out and plane a bevel between the front and top faces, as shown in Working Drawing No. 2, and make a ⅜-in. square drip-groove on the underside to prevent water from running into the joint. Screw the sill down to the bottom member of the window aperture, using 3½-in. countersunk-headed screws for the purpose. Line the remainder of the opening with planed strips of wood 2 in. wide by ½ in. thick.

The Window-frames are made of 2-in. by 1¼-in. planed joinery deal. As the windows are not very large, and therefore light in weight, an ordinary open morticed and tenoned joint can be used. The joints should be glued up and locked with dowels.

The rebate for the glass is formed by nailing ¾-in. by ⅜-in. strips of wood to the insides of the frames.

Before inserting the glass, the frames should receive a good coat of priming paint as putty will not stick to bare wood. When the paint is quite dry, glaze the windows in the usual way.

The Sashes are hung from the sides by means of 1-in. iron butt hinges. These are sunk half in the window frame and half in the lining and fixed with 1-in. No. 8 countersunk-headed screws.

Finish the window aperture by nailing strips of wood ¾ in. by ½ in. thick around the inside faces at the back to prevent the windows closing inwards, and fix a suitable window fastener.

The structure is now complete except that it should either be creosoted or painted. If paint is chosen, the building should receive a good primary coat of red lead in oil, followed by two coats of good quality lead paint of the desired colour. Creosote is an excellent preservative and is, of course, very much cheaper and easier to apply than paint.

HANDY SHELVES

Shelves are a necessity in every house, and, fortunately, shelf-making and fitting is one of those comparatively simple jobs that the man who can use a few simple tools will find little difficulty in carrying out successfully.

Prepared deal boards varying from 5 in. to 11 in. in width and $\frac{7}{8}$ in. thick are commonly used for shelves, whether they are for a humble apartment like the kitchen, for holding cooking utensils, or a more elaborate fitment for books in the study (such as the one illustrated in Fig. 1).

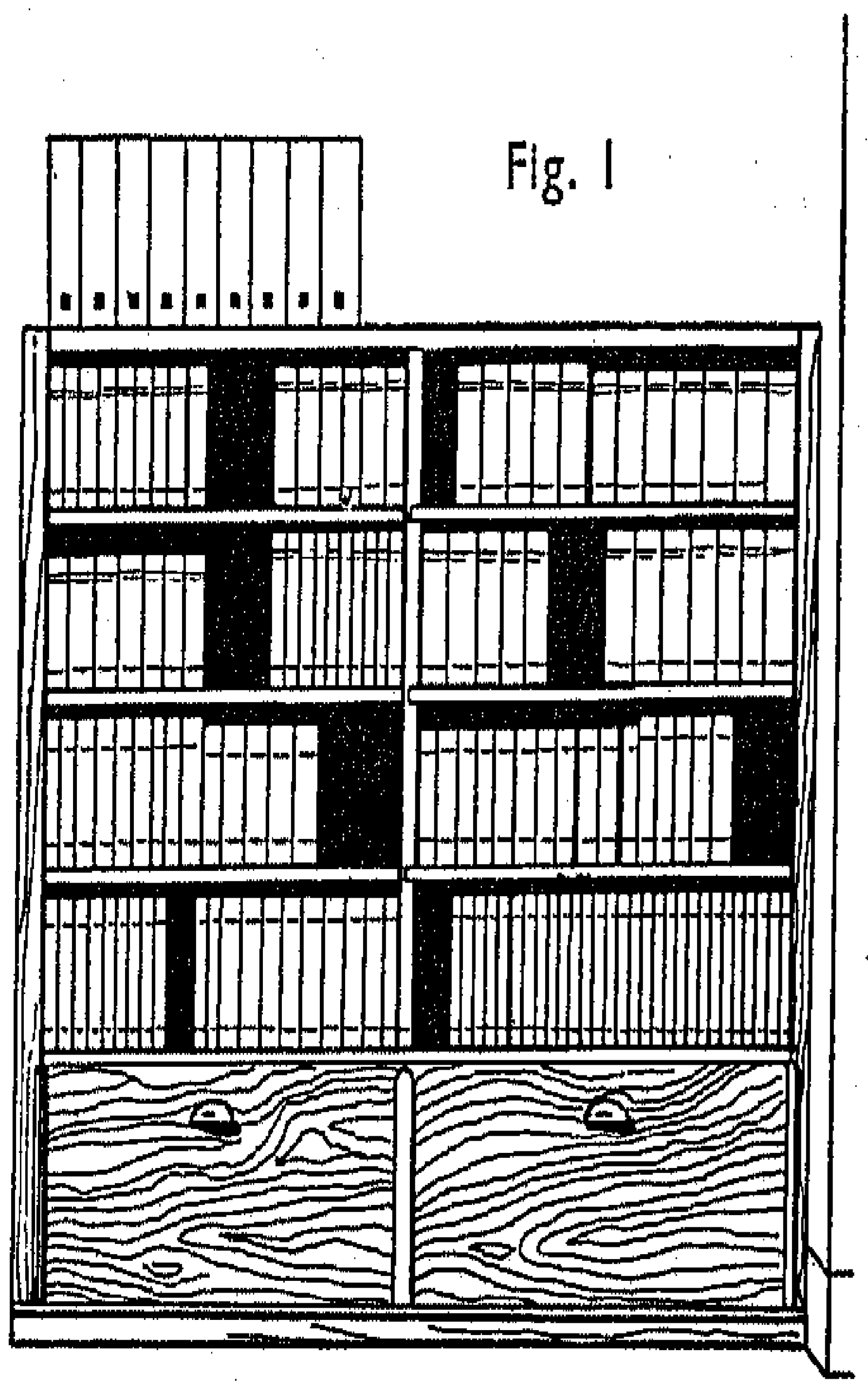


Fig. 1

The Kitchen Shelf shown in Fig. 2, 9 in. wide is fixed between the walls of a recess in a kitchen or scullery. The ends of the shelf are supported by bearers $8\frac{1}{2}$ in. in length, 2 in. wide and $\frac{3}{4}$ in. thick, neatly shaped at the front ends and painted, if desired.

It is important that the boards forming any shelf are truly horizontal and square. To ensure accuracy, a guide-line should always be marked upon the walls before the shelves are fitted. To do this, measure the height from the floor to where the tops of the bearers are to be, and make pencil marks at the points near the ends of the back wall. Draw a line across, cutting the two marked points, and trace the line round the adjacent walls by using a try-square, as indicated in Fig. 3.

If the walls are covered with ordinary plaster and the bricks are soft, the bearers may be fastened direct to the walls by driving in 3-in. nails at a distance of about 2 in. from the ends of the supports. Should the walls be cement-faced, however—as a good many walls are, especially in kitchens and sculleries—it will be necessary to drill and plug the wall to obtain a good fixing for the bearers, which are fixed by means of screws.

Having fixed the bearers, cut the board square and slightly chamfer the long sharp edges with a plane. Place the board in position and test to see whether it is level by using a spirit-level for the purpose. If the shelf is not quite true, adjustments should be made to correct any errors. The shelf can now be fastened down to the bearers by means of either nails or screws—preferably the latter.

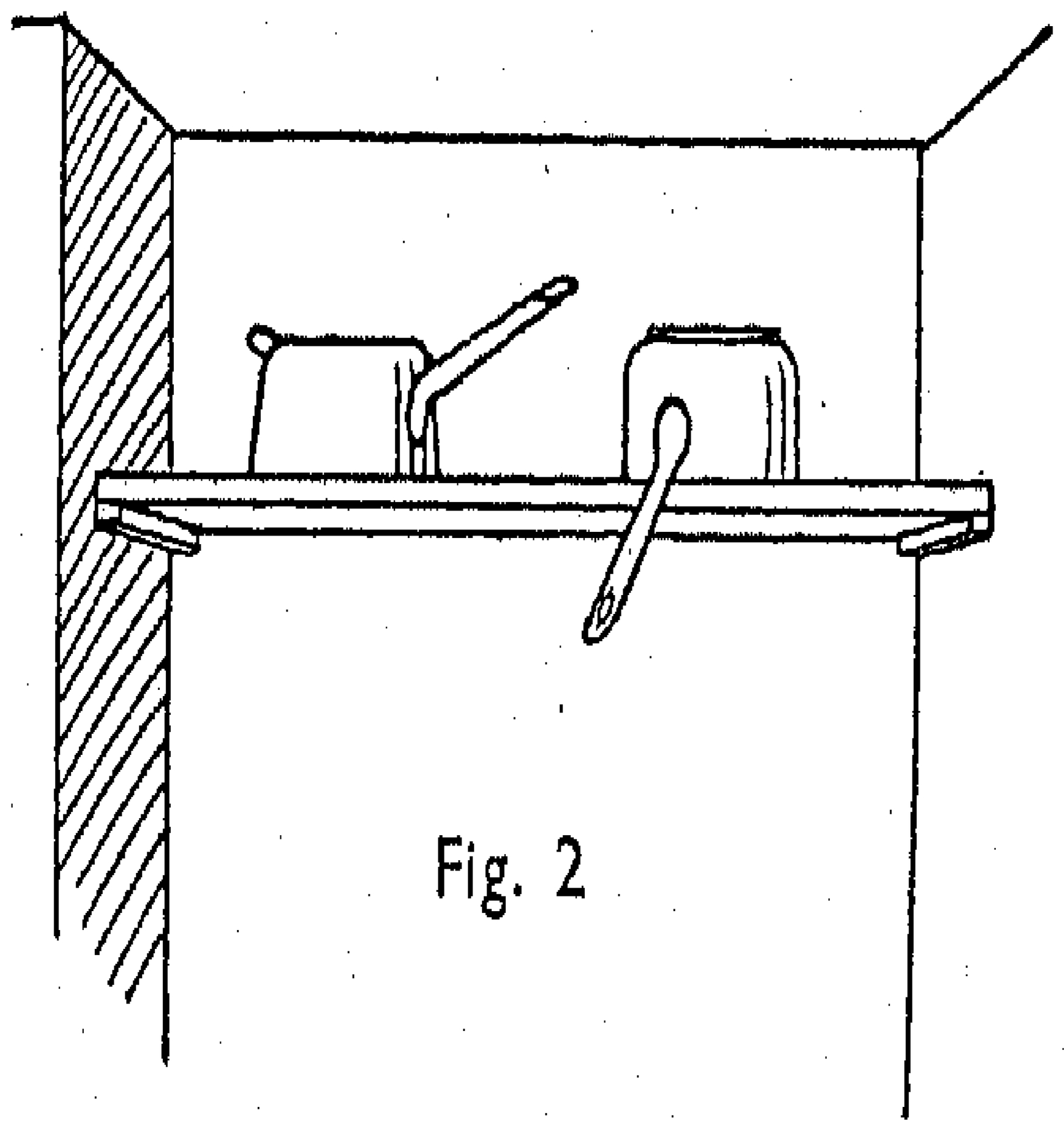


Fig. 2

If the span of a shelf exceeds 4 ft. in length, it is advisable to fix an additional support at the back; otherwise the shelf is liable to bend when carrying a heavy weight. The extra support can be obtained by fitting a batten at the back, or an iron or wooden bracket could be fixed at the middle, as represented in Fig. 4.

One of the simplest methods of fixing shelves for supporting light weights to a wall is to use iron brackets, which can be obtained for a few pence. The brackets should not be fixed directly upon the wall, as a much better job is obtained by first fixing two or more vertical battens to the wall and then mounting the brackets upon the battens.

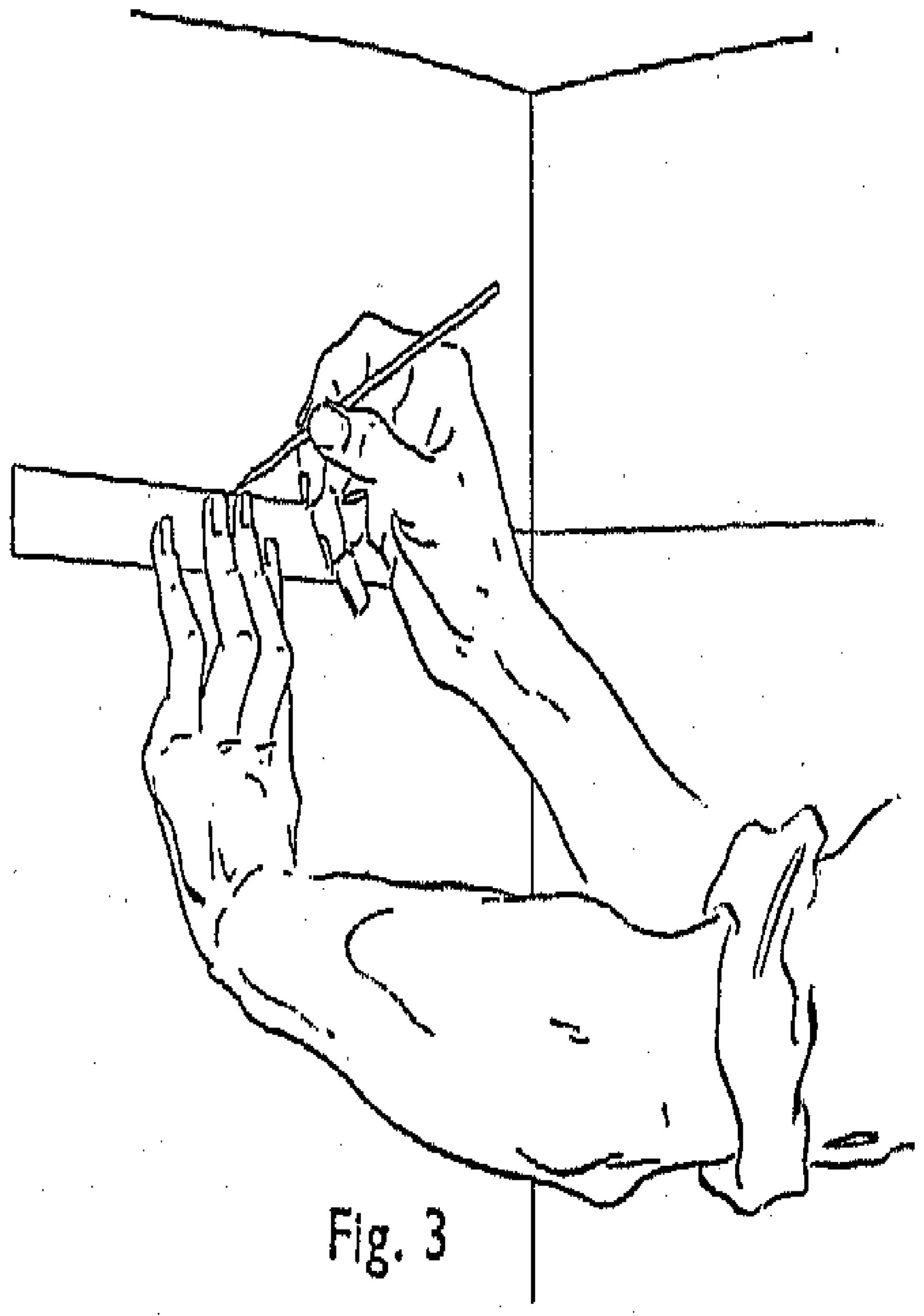


Fig. 3

The Uprights can be made from suitable lengths of $1\frac{1}{2}$ in. by $\frac{3}{4}$ in. planed batten, cut to length and neatly finished by chamfering the front edges and rounding the corners. A recess should be cut at the back of the boards to allow them to lie flush with the wall.

Where extra strong shelves of over 10 in. in width are required, special wooden brackets should be employed. Such a bracket is illustrated in Fig. 5. When it is desired to fit bookshelves in a recess of a living-room, the books should not be allowed to come in contact with the walls. In such a case it is better to make a self-contained fitment, as that illustrated in Fig. 1. A suitable height for such a fitment would be 6 ft. or so, but this is an arbitrary figure, as much depends upon individual requirements.

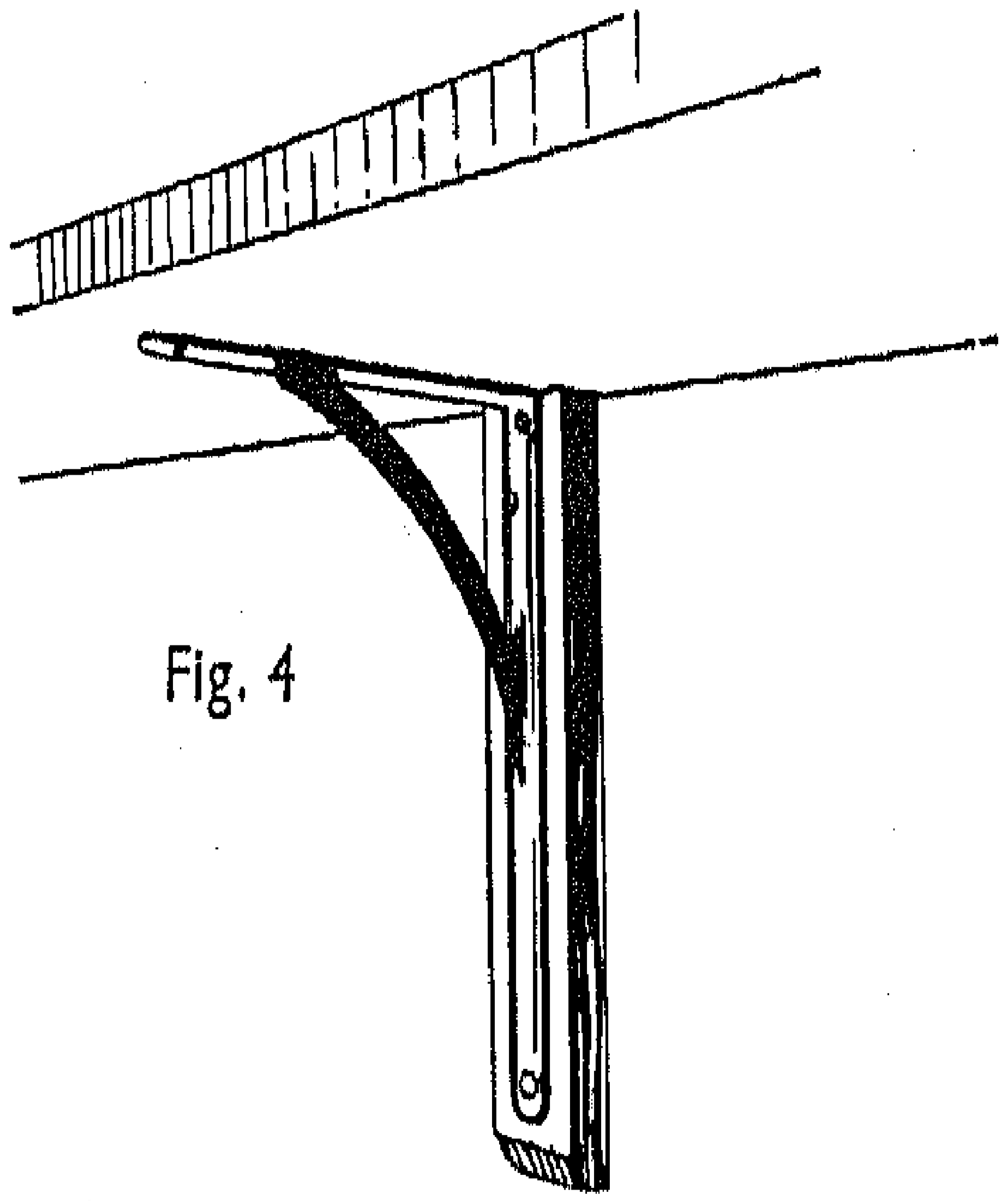


Fig. 4

The shelves can be supported by means of narrow bearers about $\frac{3}{4}$ in. wide screwed to the inside faces of the uprights (as illustrated at A in Fig. 6), or the ends of the boards housed into trenches in the manner shown at B. The former method is the simpler, as it only entails cutting and screwing on the bearers at the desired distances apart; but it has the disadvantage that extra head-room must be allowed

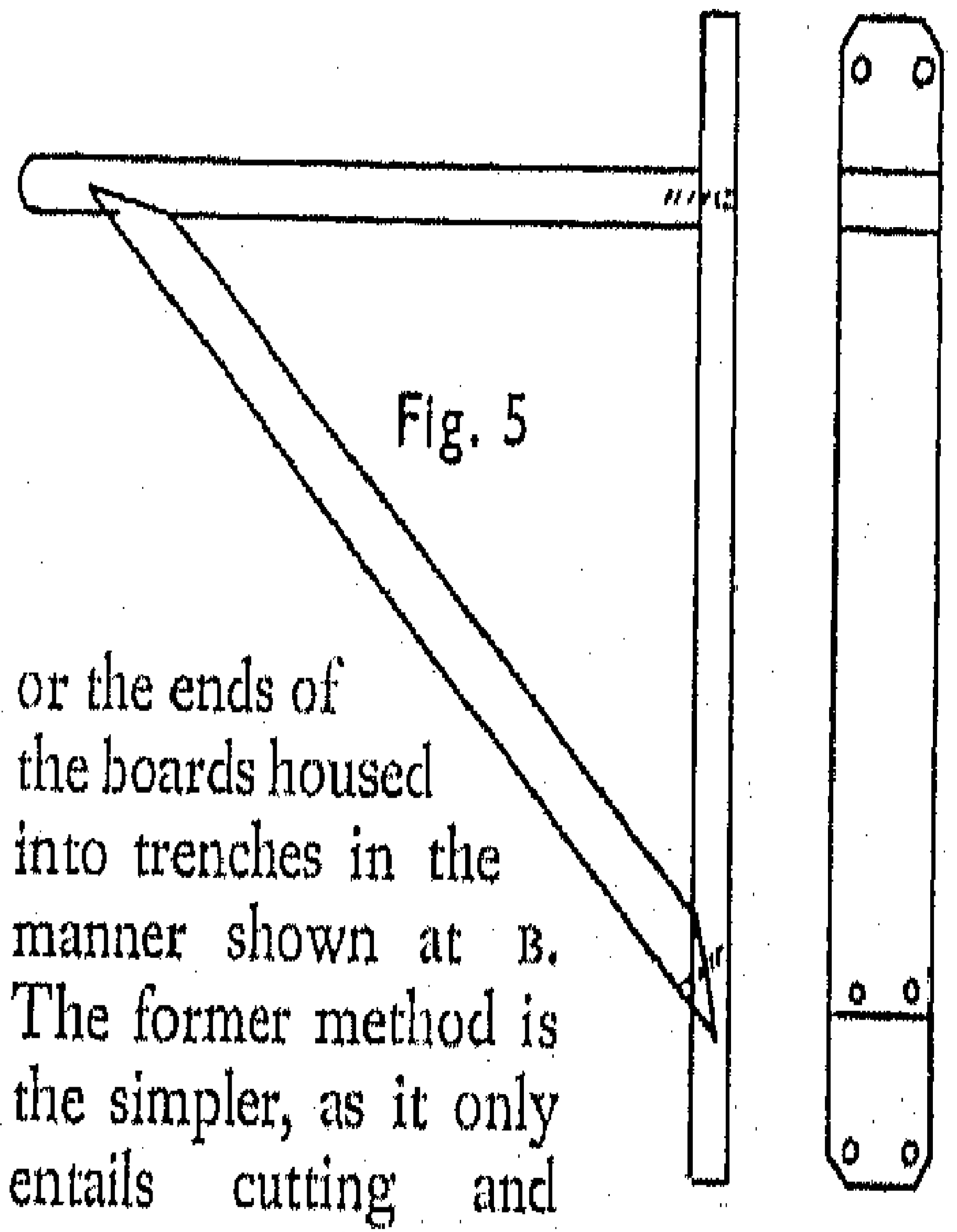


Fig. 5

to enable the tops of the books to clear the bottoms of the bearers supporting the shelf above. The housing method, although not so simple to accomplish, makes a much better job and allows the shelves to be fixed closer together.

An ordinary through-housed joint can be used or, better still, a stopped housed joint, which has the additional advantage that it forms a neater joint on the front edges.

Where a stopped trench is employed, the grooves should stop at about ¾ in. from the front edges of the uprights, but should through-housing be resorted to, all that is necessary is accurately to mark the positions for the recesses, cut across the boards with a tenon-saw, and remove the waste with either a chisel or a trenching-plane. The depth of the trenches in both cases should be ¼ in. and as wide as the thickness of a shelf. If stopped housing be adopted, it will be necessary to cut the front ends of the shelves back for a distance of ¾ in., and when cutting the boards to length, an extra ½ in. must be added to their apparent lengths for insertion into the grooves.

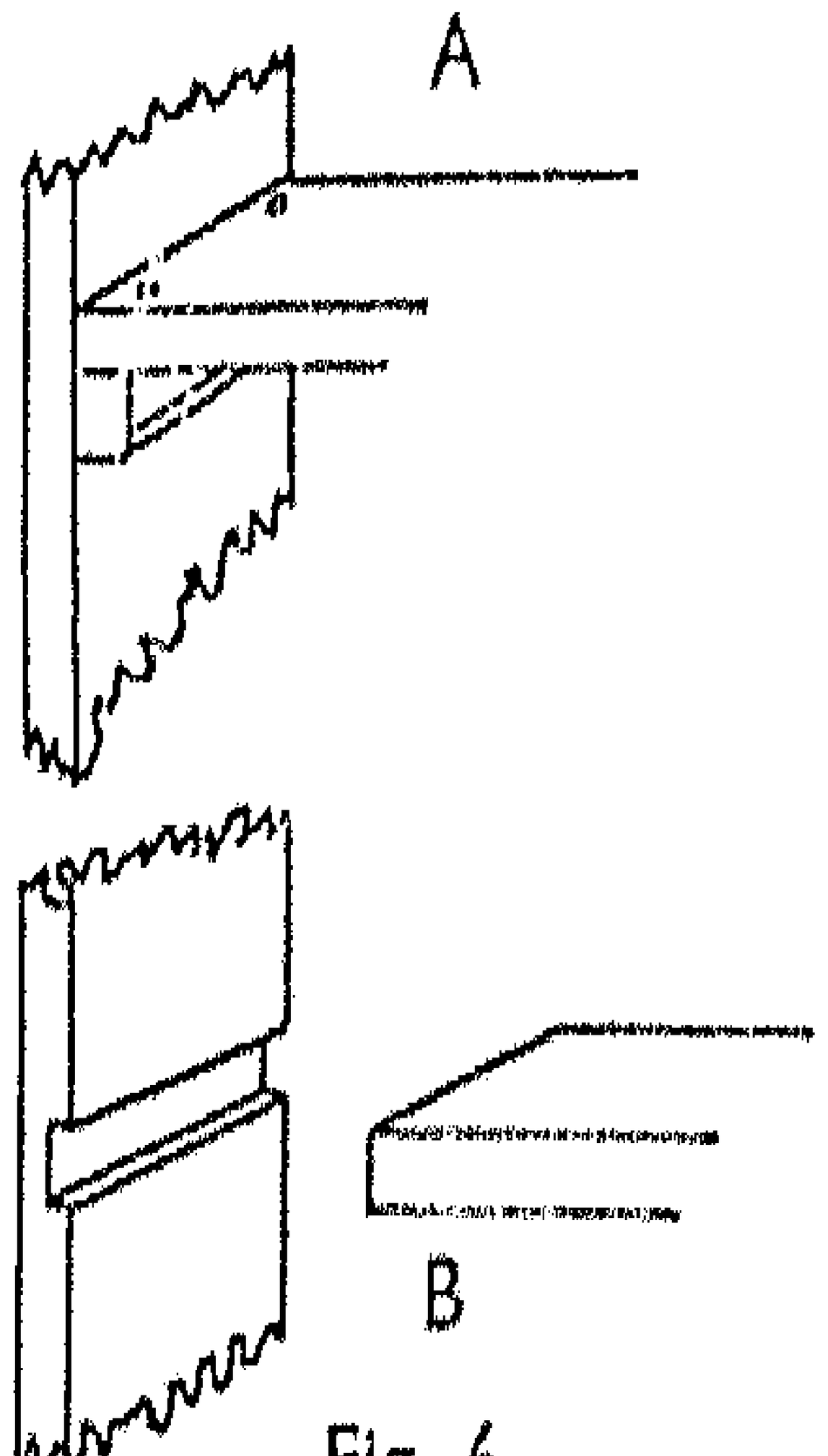


Fig. 6

In designing bookshelves of this type it should be noted that the bottom shelf should be raised about 2 in. above the floor, the intervening space being covered with a strip of wood or plinth about ½ in. thick.

A Useful Hanging Bookshelf for holding small books is illustrated in Fig. 7. The centre compartment between the top and middle shelves is fitted with a door, and will be found handy for holding oddments. Oak could be used with advantage for its construction, in which case it could be stained and wax polished.

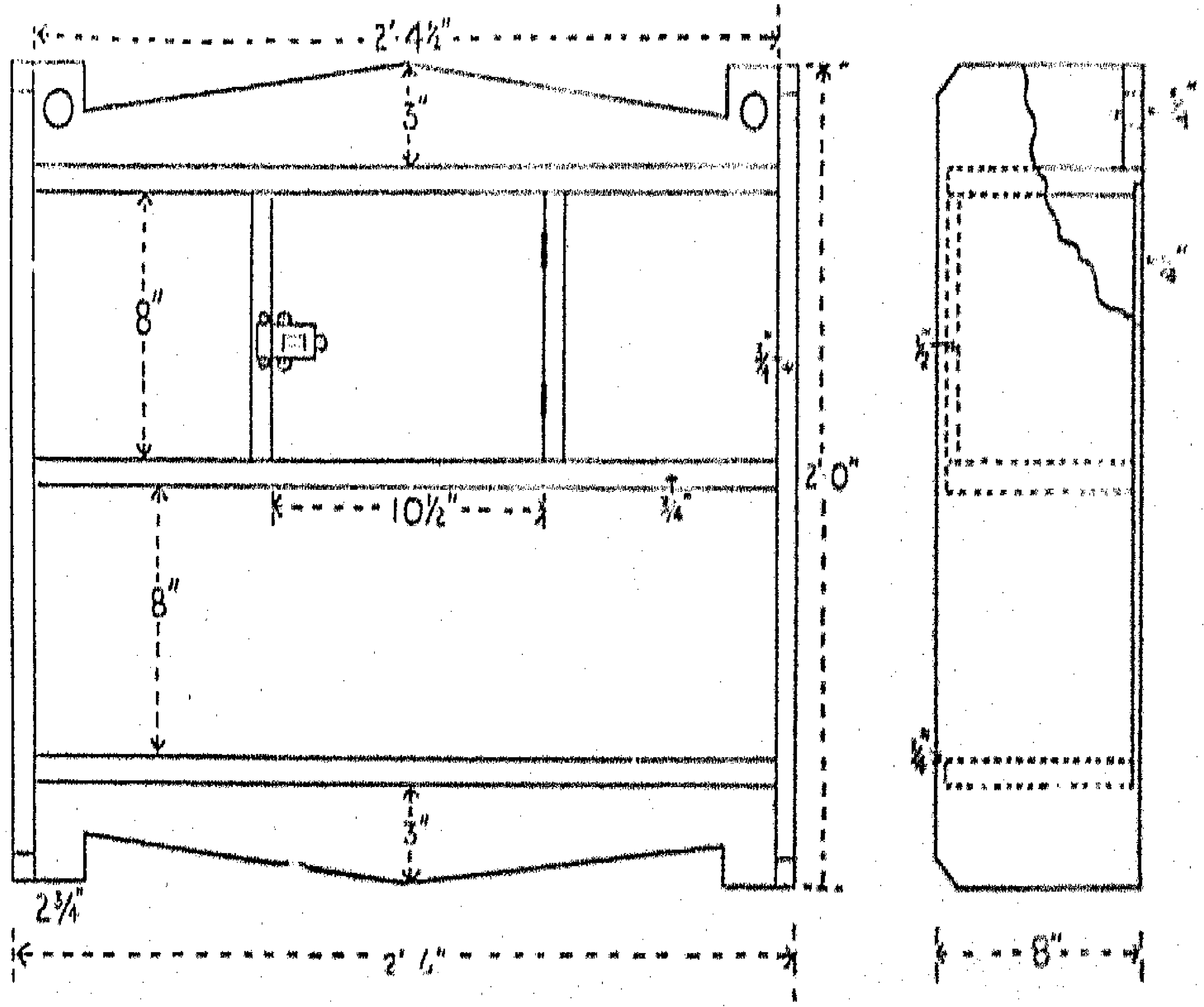


Fig. 7

A PLAIN LEDGED DOOR

THE door shown in Fig. 1 is the simplest type of door to construct, and is known as a plain ledged door. Its use is generally confined to work where appearance is of little consequence, as instanced in poultry-houses and structures of a similar kind.

The materials necessary to construct such a door include a few tongued and grooved V-jointed matched boards, three cross-battens and a few 1½-in. wire nails.

For a light door measuring 4 ft. 6 in. high by 2 ft. wide, six matched boards 4½ in. wide by ⅝ in. thick would answer the purpose and if they are kept together by means of three battens each 3 in. wide and ⅝ in. thick, the resulting door would be suitable for a small poultry-house.

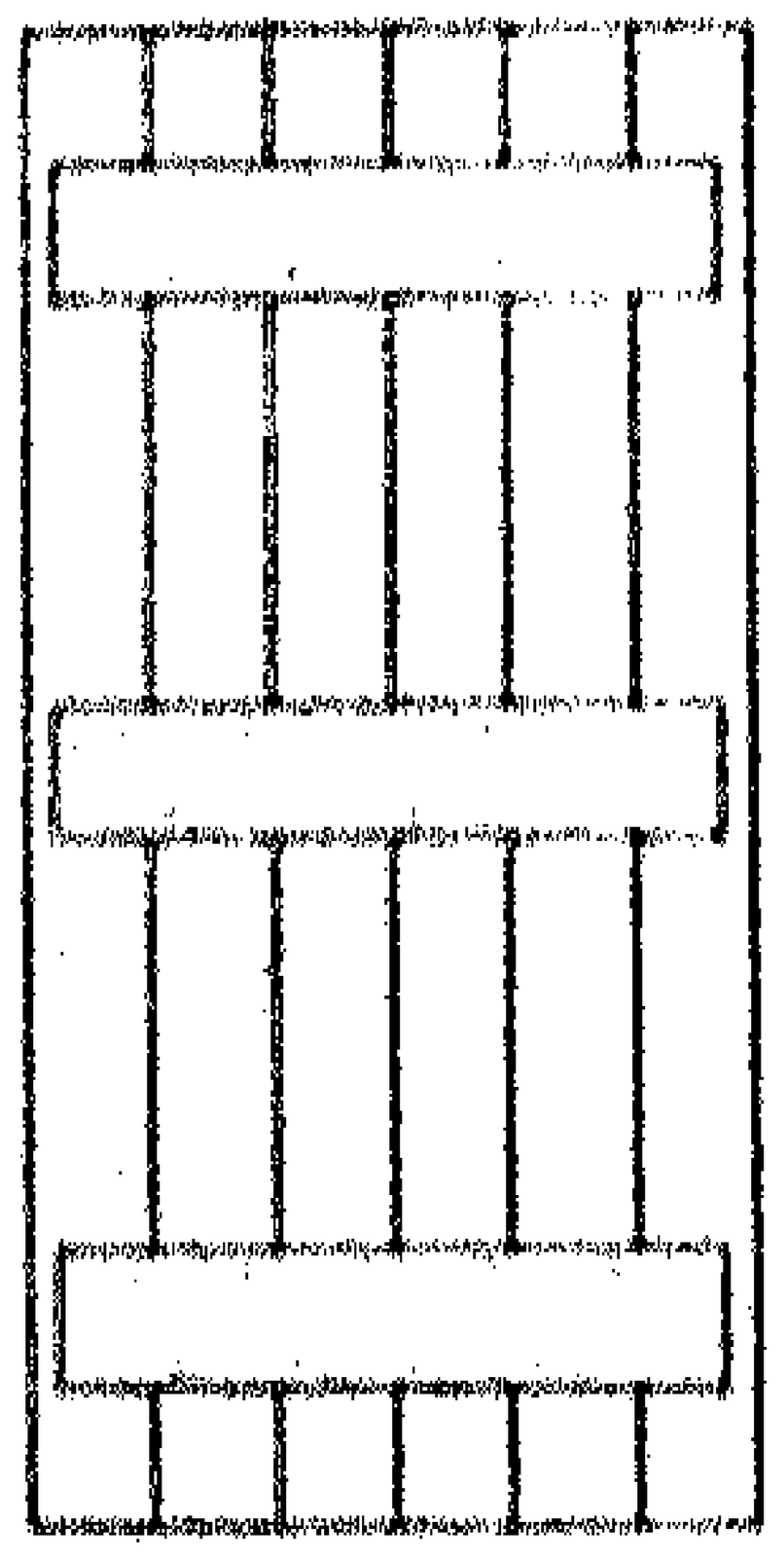


Fig. 1

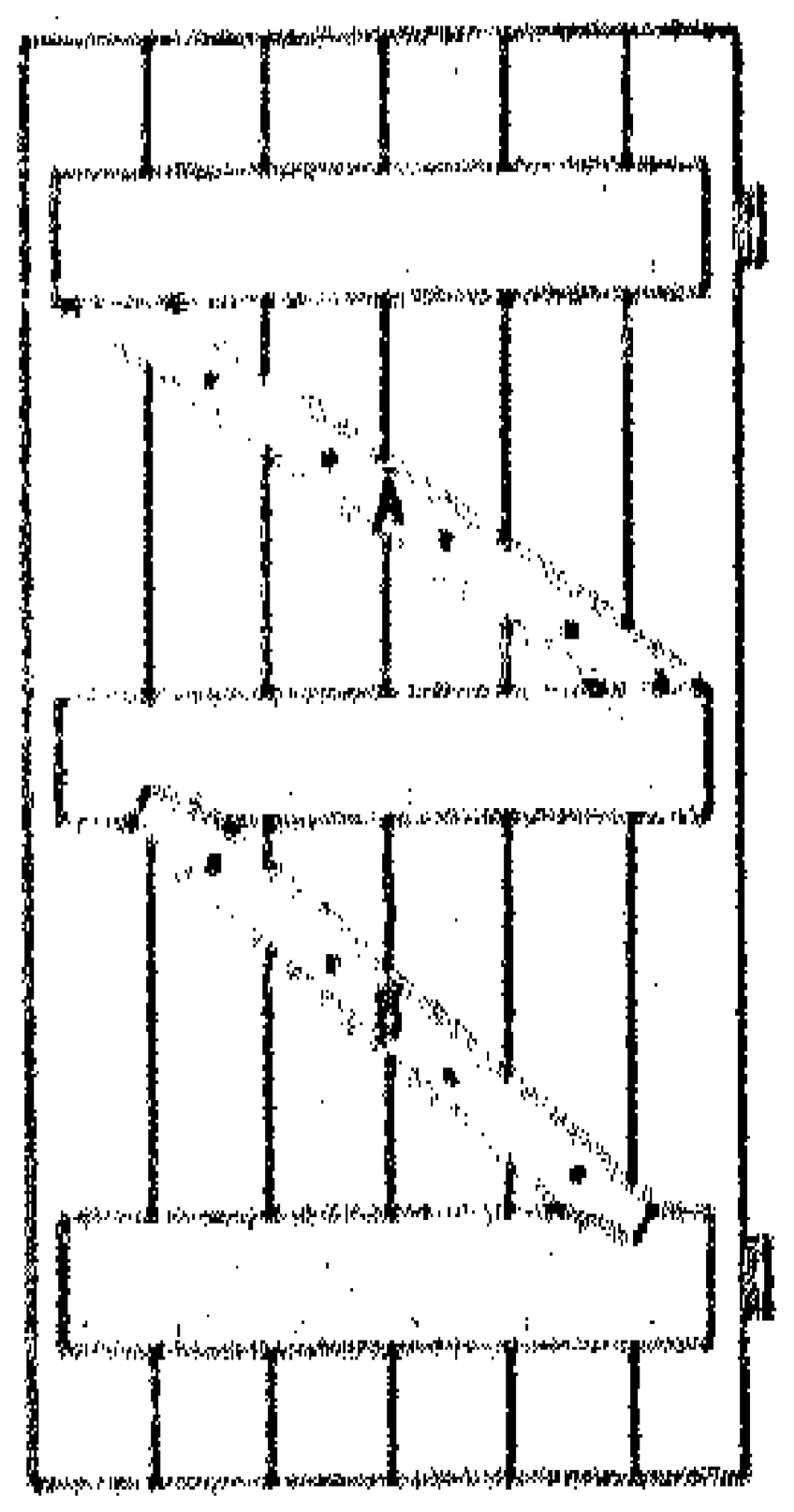


Fig. 2

An Important Point to bear in mind.—In estimating the number of boards required for a given width of door of this description, do not overlook the fact that the effective width of a matched board is ½ in. less than its listed width and it also loses ⅛ in. in thickness for planing purposes. Thus a board whose listed thickness is ⅝ in. only "holds up" to ½ in.; consequently, in the door under consideration, the width of each board at the joint will be 4 in. and the thickness only ½ in.

From this it will be observed that the total width of the boards when joined will be 2 ft. ½ in. and as it is necessary to remove the tongue of the first board, the resulting width is 2 ft.

Preparing the Boards.—The orthodox method of preparing the boards preparatory to fixing is to remove the tongue of the first and the groove of the last, but if the latter is done, its removal will make the width of the door ½ in. less than that required.

As the grooved edge comes on the hinged edge of the door and is therefore not likely to be broken off, its removal on a small door of this description is unnecessary.

The boards should measure an inch longer at each end than their final dimensions to allow for cutting off square after fastening to the battens.

In constructing the door, the first thing to do is to prepare the ledges, as the cross-battens are called. The length of these should be 1 in. less than the total width of the door to allow clearance for the usual ½-in.-thick door-stop which is fixed to the inside faces of the two uprights and top of the door-frame.

If the battens are made from rough sawn wood, clean it up with a plane and neatly chamfer the outside edges. A few minutes spent on small details of this kind, although of seemingly little importance, differentiate between a workmanlike job and a shoddy one.

To Assemble the Door, first plane off the tongue of the outside board and then mark the positions of the ledges on the board, not forgetting the ½-in. overlap as previously mentioned. Use the square in marking, and then screw the board to the ledges. Next turn the work over so that the face side is uppermost and place the remaining boards in position. Mark light pencil-lines across the boards to act as guide-lines for the nails.

As it is usual either to paint or creosote the completed door, it is a wise plan to give the joints a coat of the covering medium during erection, as it is obviously impossible to treat these parts afterwards.

Nail the boards to the battens, taking care in so doing to force each one tightly against its neighbour. Now clinch the ends of the nails. Square lines across the face at the top and bottom of the door and saw off the waste.

In cases where a stronger and more robust door is required, use thicker boards and stouter and wider ledges, and fix a couple of braces diagonally between the ledges, as in Fig. 2, A and B. The braces keep the door perfectly rigid and prevent it from sagging at the outer edge.

The method of construction is similar to that adopted in the plain ledged door, the braces being fitted to the ledges after the boards have been fixed. The ends of the braces can either be let in square with the ledges or at an angle. They should be cut accurately to obtain a perfectly tight fit and then fixed in position and secured by nails driven through the face of the door.

Doors of this description are usually hinged by means of T hinges, or cross garnets, as they are termed, screwed to the face of the door in such a position that the fixing-screws can be driven into the ledges.

A CABINET FOR SCREWS

A GREAT number of practical men who ought to know better store their nails and screws jumbled together in odd boxes, with the result that a considerable amount of time is wasted by having to search for a particular-sized screw. This state of affairs can be obviated by making the simple cabinet shown in the accompanying illustration (Fig. 1), and following the detailed drawings appearing in Working Drawing No. 4.

The construction of such a cabinet calls for no exceptional skill, and it can be made cheaply with the aid of a few simple tools in a few hours.

The main feature of the cabinet lies in the method adopted for supporting the drawers. This is attained by allowing the side edges of the bottoms of the drawers to project a trifle beyond the sides, the projections so formed sliding into narrow grooves cut on the inner faces of the sides of the cabinet. This method of construction, although not exactly orthodox, will be found very useful for constructing all kinds of cabinets where utility is of greater consequence than appearance.

The Drawers.—Another distinguishing feature of the drawers is that the fronts are provided with circular recesses, bridged across by narrow strips of brass, the ends of which are let in flush with the surface. This does away with ordinary projecting knobs or handles, saves space and allows the door to be easily fitted.

The following list gives the finished sizes, etc., of the parts.

Item	*No.*	*Size.*			
		ft. in.	*in.*	*in*	
Top	1	1 0	× 8½	× ⅝	
Bottom	1	1 0	× 8½	× ⅝	
Sides	2	1 0¾	× 7½	× ⅝	
Back	1	1 0¾	× 9¾	× ⅛	plywood
Back supports	2	1 0¾	× ¼	× ¼	stripwood
Door	1	1 0¾	× 9¾	× ½	
Small drawer fronts	4	9¾	× 2⅜	× ⅜	
„ „ backs	4	9¾	× 2⅜	× ⅜	
„ „ sides	8	6¾	× 2⅜	× ⅜	
Large drawer front	1	9¾	× 2⅝	× ⅜	
„ „ back	1	9¾	× 2⅝	× ⅜	
„ „ sides	2	6¾	× 2⅝	× ⅜	
Brass handle strip	5	2¼	× 3/16	× 1/16	
Brass butt hinges	2	1	× ⅝		

The top, base and sides of the fitment can be made of either best quality deal, or better still, whitewood ⅝ in. thick, the back being a panel of plywood. The drawers are made of ⅜-in. stuff except the bottoms, which are cut out of ⅛-in.-thick plywood.

Start by preparing the cabinet sides. Carefully mark and saw the ends perfectly square and from the top ends mark the positions for the grooves, as indicated in Fig. 1. (Working Drawing No. 4.) The grooves should be a trifle over ⅛ in. wide and 3/16 in. deep. Cut the grooves by first sawing across on the inside of the marked lines by using a fine-toothed tenon-saw and then remove the waste with a very sharp ⅛-in. chisel. As the grooves must be nicely finished to ensure the smooth running of the drawers, the recesses can be finished with glass-paper by wrapping the paper round a slip of wood and applying it edgewise into the groove.

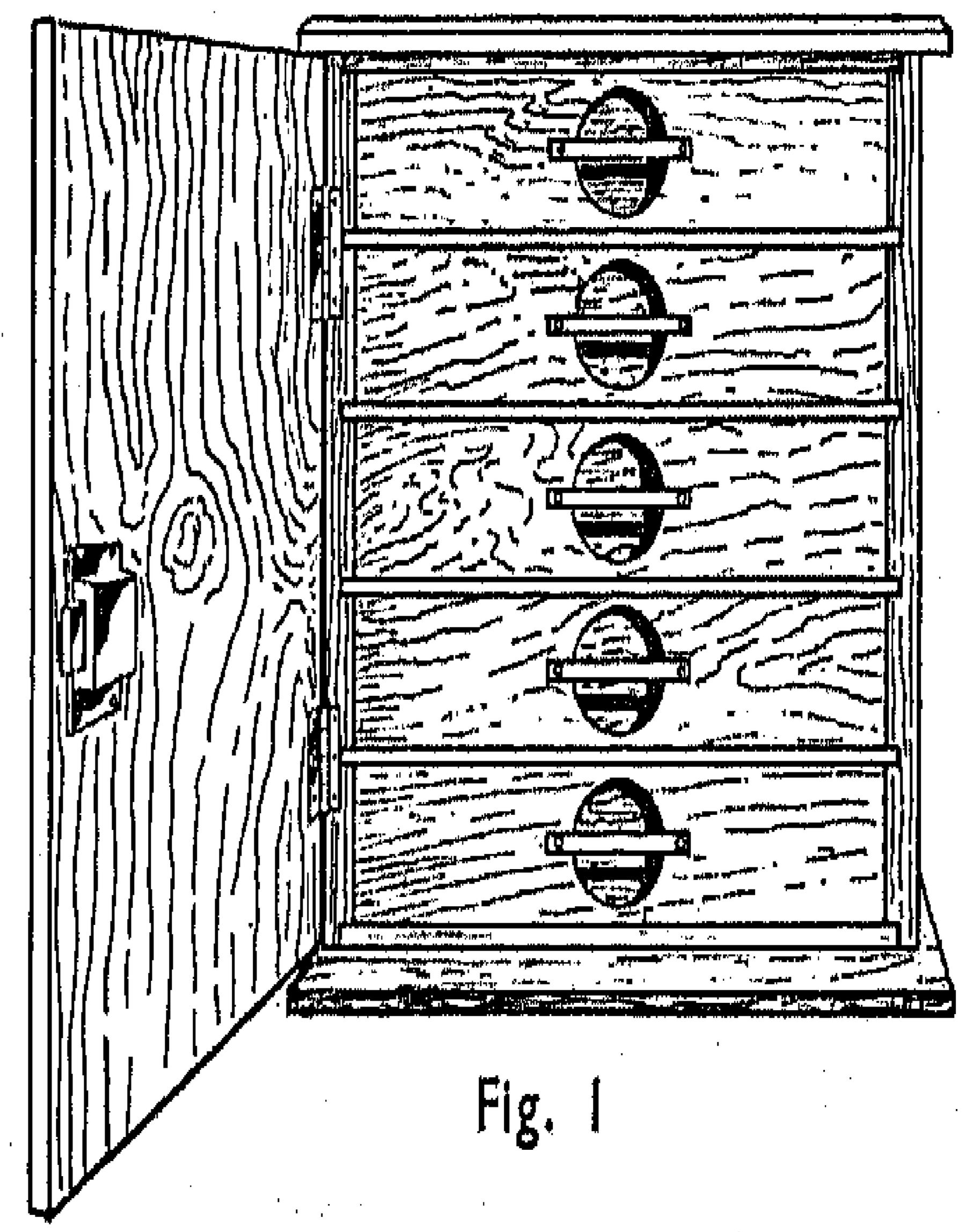


Fig. 1

The pieces forming the top and bottom are identical in size. When these have been carefully prepared by cutting them accurately to the dimensions shown in the drawings, chamfer the front and side edges to an angle of 45° as shown.

Reference to the drawing shows that the back panel is fitted flush with the back edges of the cabinet. This is attained by fastening pieces of ¼-in. by ¼-in. stripwood set ⅛ in. back from the long edges of the inside faces of the uprights.

The door is a plain piece of wood 1 ft. ¾ in. in length, 9¾ in. wide and ½ in. thick. Run the plane lightly over the front edges to remove the "arris," as the sharp edge is called.

The parts should now be thoroughly glass-papered and then assembled. Either nails or screws can be used for this purpose, but screws are preferable as they are stronger.

The best way to construct the four small drawers is first to prepare the material for the fronts, backs and sides, in one or two strips $2\frac{3}{8}$ in. wide, before cutting them to size.

The ends of the front pieces are cut away on their inside faces to house the ends of the sides, as shown clearly in the detailed drawing of a drawer. To make the housing, all that is necessary is first to mark a line across each back face $\frac{3}{8}$ in. from the ends and then scribe another line on each end $\frac{1}{8}$ in. from the front face. Saw across at the marked lines and smooth the recess with glass-paper if necessary.

The bottoms of the drawers are pieces of $\frac{1}{8}$-in.-thick plywood, cut accurately and squarely to size. Now prepare the parts for the large drawer, not forgetting that its depth is $\frac{1}{4}$ in. deeper than the smaller ones.

Next bore the recesses in the fronts for the handles, using a brace and $1\frac{1}{4}$-in. diameter centre-bit. Take care when making these, otherwise you may have the misfortune to cut right through the wood. It is a wise plan to stop boring when $\frac{1}{8}$ in. of the material has been removed and then to scoop out the remaining waste with an externally-ground gouge. Mark and cut out the shallow rectangular recesses on each side of the circular ones to allow the brass strips to lie flush with the surface.

Great care must be exercised in assembling the drawers to ensure that they are perfectly square. Nail the back to the two sides and then fix the front. One-inch oval brads are the best type of nail for this purpose as the heads should be punched down below the surface after assembly. Before attempting to fix the plywood bottom to a small drawer scribe pencil lines $\frac{1}{8}$ in. from and parallel to the short edges to serve as a guide when nailing the bottom to the frame. The bottom can then be placed in position, using the marked lines as a guide, and fixed by means of $\frac{3}{4}$-in. panel pins driven in on the skew or dovetail fashion. The bottom edges of the large drawer are fixed flush with the edges of the frame.

The Handles are made of $\frac{3}{16}$ in. by $\frac{1}{16}$ in. brass strip. Cut these to the required length and drill a hole near each end to take a $\frac{1}{4}$-in. No. 3 brass countersunk-headed screw. Fit the prepared strips into the recesses in the drawer-fronts and fix them firmly with the screws.

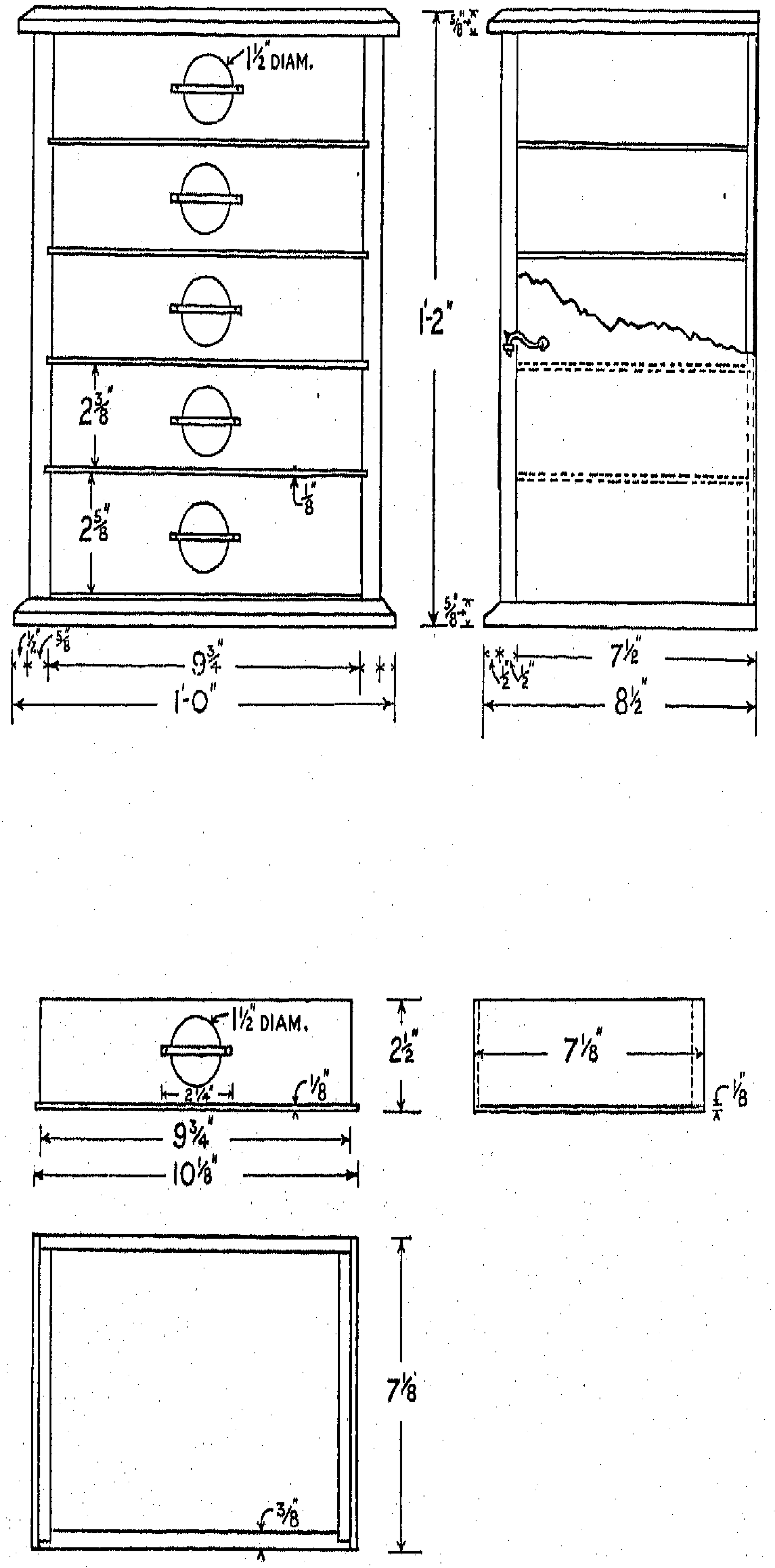
Punch the heads of the brads in the sides of the drawers to a depth of about $\frac{1}{16}$ in. below the surface, as the drawers may have to be eased when fitted.

Remove the sharp square edges of the backs of the drawers by placing the drawers in a normal position and paring the edges with a chisel held vertically.

Now insert the drawers into their respective divisions in the cabinet and ease them if necessary by planing down the high parts. The drawers can be divided into a number of compartments if desired, to take screws and nails of various sizes, and other odds and ends. The divisions are made of plywood and fastened with liquid glue.

The final operation consists in fitting the door on the left-hand side. This is hung in the usual way by sinking the hinges half into the edge of the door and half into the edge of the upright. To keep the door shut a small hook fastened to the side, which engages in an eye screwed into the edge of the door is all that is required.

If a stained finish is desired, it is advisable thoroughly to smooth the surfaces with fine glass-paper before applying the finishing medium.



CABINET FOR
NAILS & SCREWS

WORKING DRAWING No. 4

A TOOL RACK

MUCH time is saved and annoyance obviated if the tools required are ready at hand and yet so kept in a safe place that their sharp edges are not injured.

A self-contained tool rack, which can be hung on the wall or screwed to the back of the bench, is shown in the accompanying drawings. The rack may be of a length suitable to the position it may have to occupy or the number of tools to be accommodated.

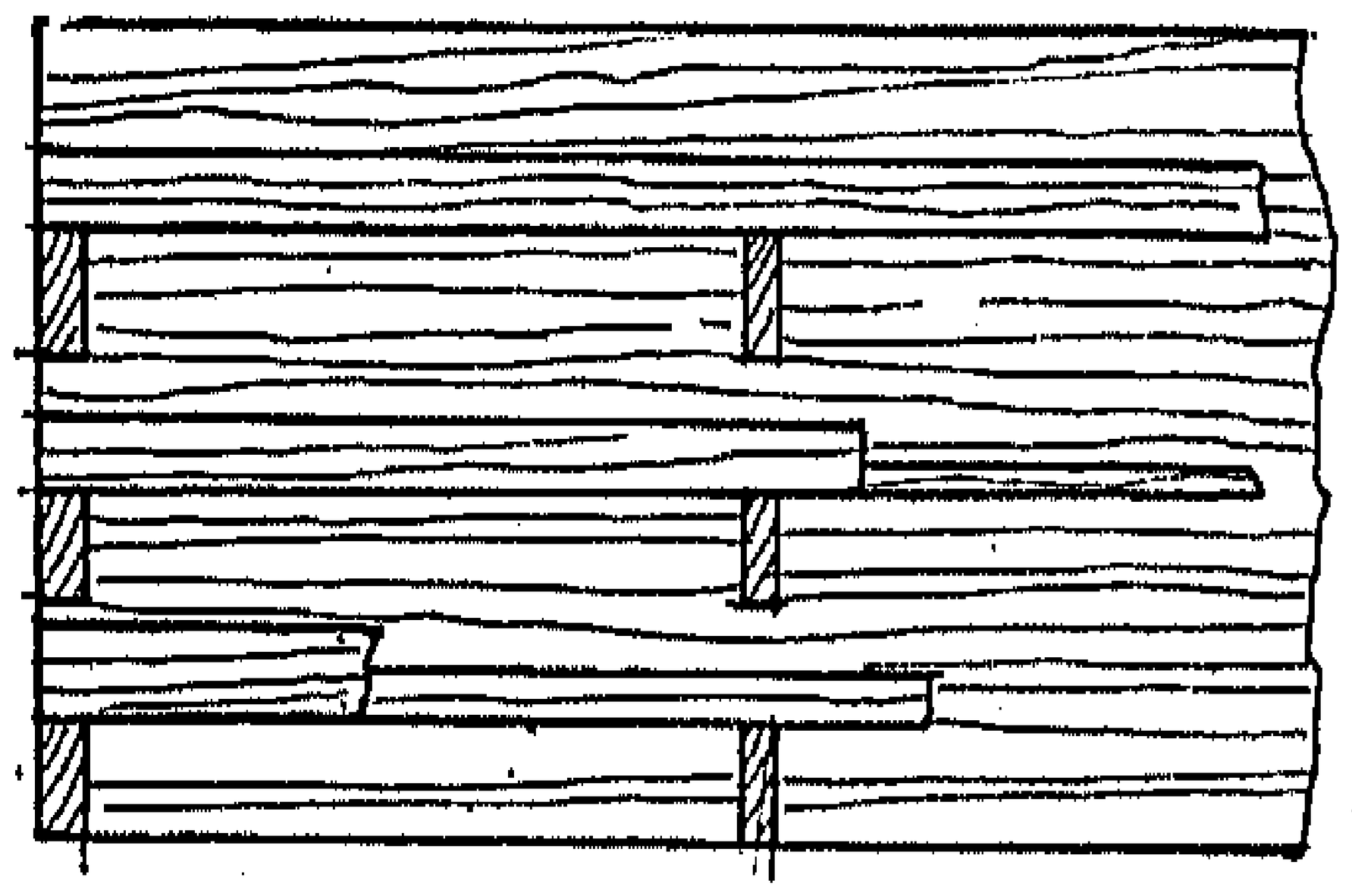


Fig. 1

Fig. 1 gives part of a front view and Fig. 2 an end view, while a perspective illustration is shown in Fig. 3.

The Back Board consists of two 9-in. by ¾-in. ordinary prepared deal boards, fixed together at the back by battens ½ in. thick and 2 in. wide screwed to the two front boards.

If the rack is to be fastened to the back of the bench, the battens may be extended down for 9 in. or more to screw to the back board of the bench, in which case the battens should be 1 in. thick.

The Top Rack consists of two lengths of 1-in. by ½-in. strip nailed to triangular brackets made out of ¾-in. deal, or hardwood for preference. The brackets are all alike and sawn out of a length of wood 3 in. wide, as indicated in Fig. 4, which will thus cut up without waste. The angle is 45°. One edge of the bracket is 3 in. long (the width of the timber) and the other is 4 in. The 4 in. edges are screwed to the backboard and the 3 in. ones support the racks and shelves.

It will be noticed that by sawing out the brackets, as shown in Fig. 4, the screws which hold them to the backboard do not enter the end grain, the shelves and racks being supported on the end grain.

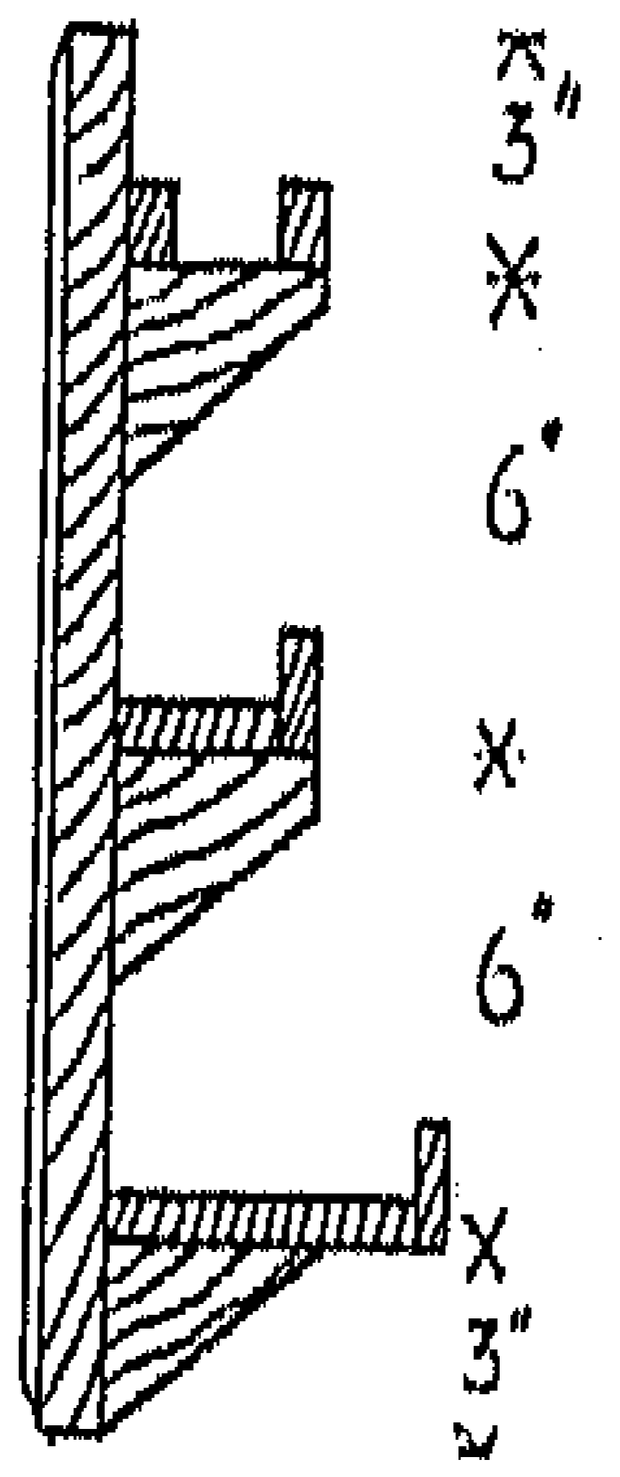


Fig. 2

The top rack, which is suitable for holding such tools as files, chisels, bradawls, etc., should not have the two rails parallel. They should be 1¼ in. apart at one end and ¼ in. apart at the other. This arrangement enables thick-handled tools to be accommodated at one end and ones fitted with thin handles—which would fall through the wider end—at the other end of the rack.

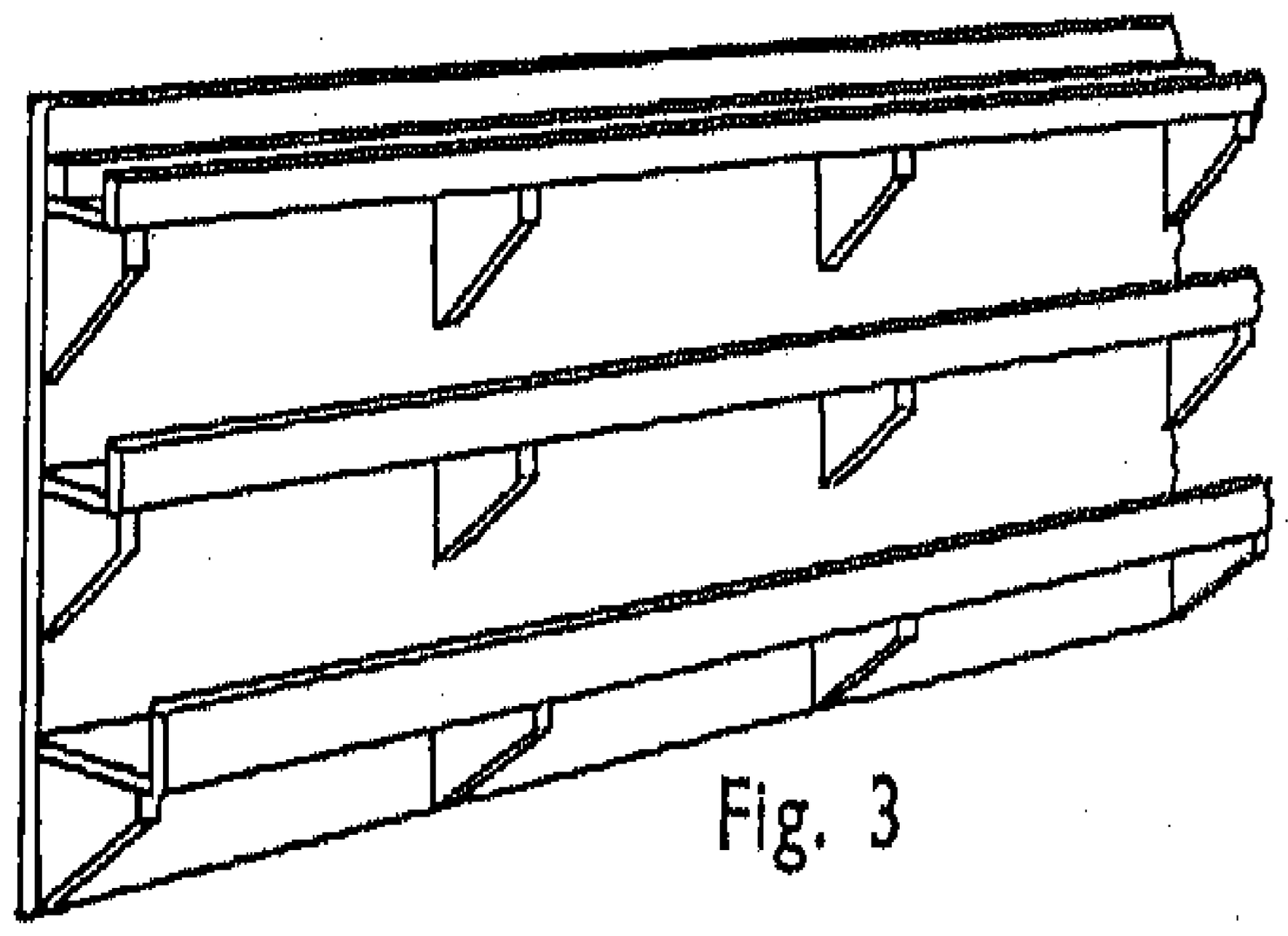


Fig. 3

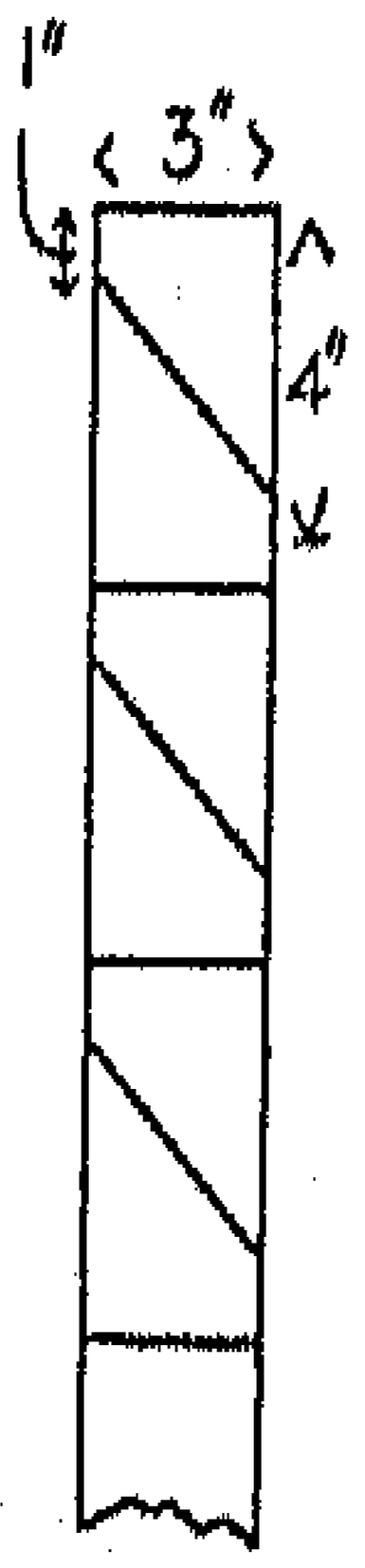


Fig. 4

The brackets should be 18 in. apart.

The lower racks are really shelves with ledges. They are intended for holding such tools as do not conveniently fit in the top rack. They may be partitioned, if found desirable. The middle one is a board 3 in. wide by ½ in. thick and the lower one of the same thickness, but 6 in. wide. The latter will hold such tools as planes, mallets, and odds and ends which may be more conveniently stood than hung.

If the two lower shelves are made shorter by about 18 in. from one end, the top rack can accommodate small saws and even a small-sized handsaw.

Wire nails or oval brads should be used for fastening the shelves to the supports.

A CORNER TABLE

A SUBSTANTIAL corner table is a very handy piece of furniture to have in the kitchen or scullery, since it occupies very little room and has no corner projections. The one described in the following paragraphs is suitable for accommodating such things as a mincer or other small domestic machine requiring a good support.

Fig. 1

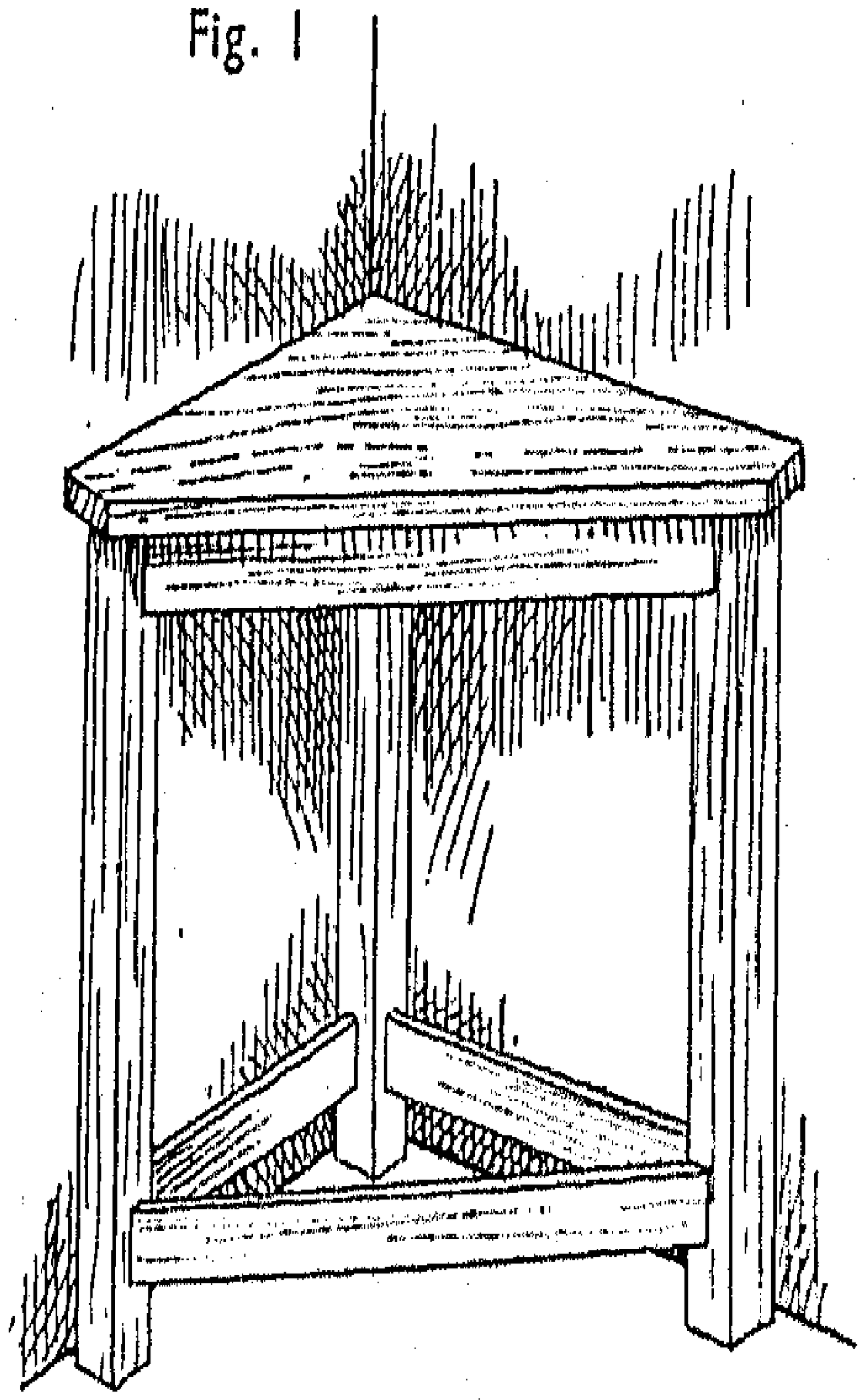


Fig. 1 shows the table in position. The legs come ¾ in. away from the walls to allow for the skirting-boards, and the table-top projects ¾ in. to enable it to lie snugly against the wall.

The illustration shown in Fig. 2 is a plan view of the table with the top removed to show the general arrangement of the tops of the legs and frame. The legs are made of 2-in. by 2-in. yellow deal, 2 ft. 9 in. long and fixed at a distance of 2 ft. apart at the sides, measured over the width of the legs, as shown.

The top is made out of three pieces of 1-in. timber, each 7 in. wide, and the depth of the table from the front edge to the back corner is 1 ft. 9 in. The top rails are 2½ in. wide and are ½ in. thick.

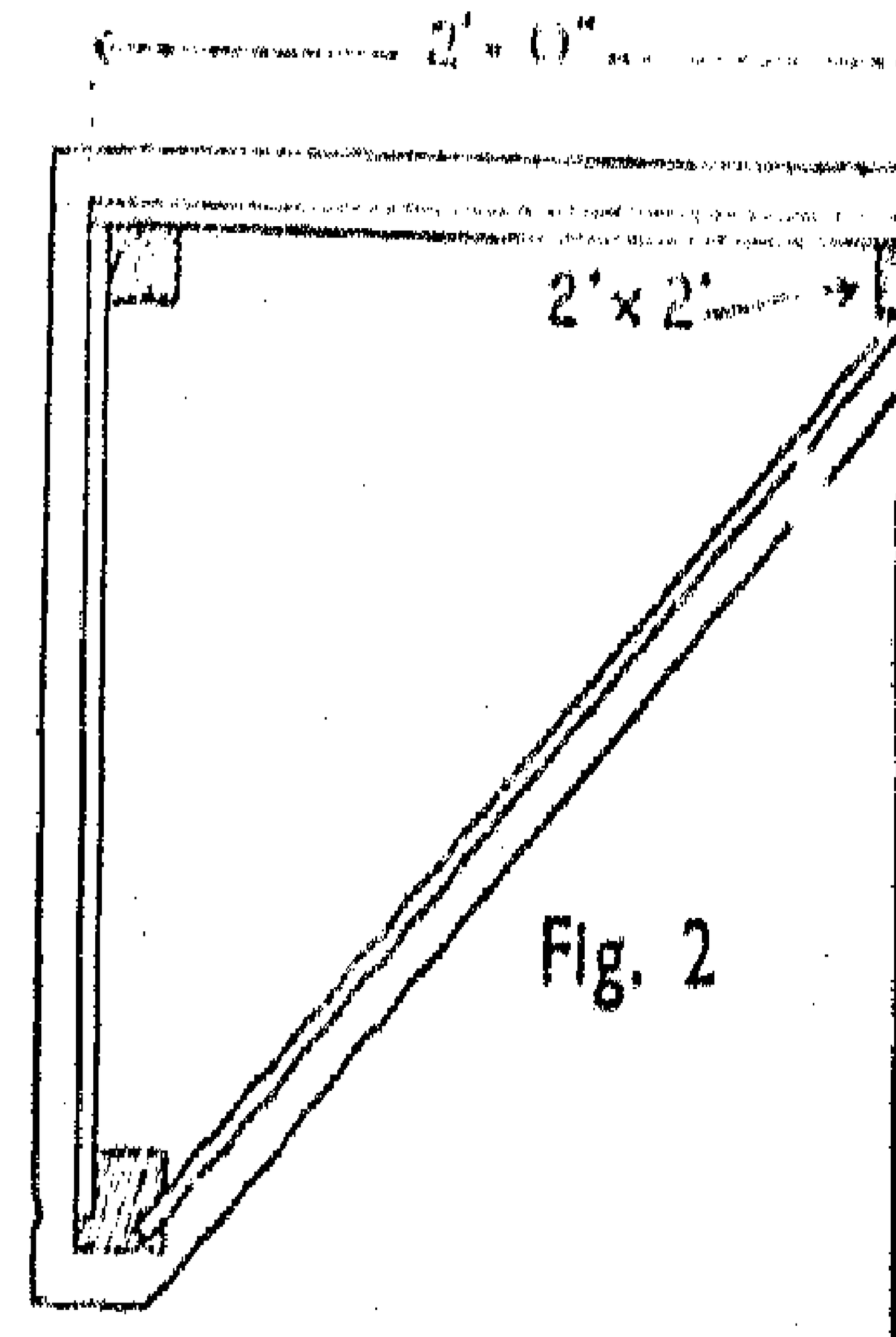


Fig. 2

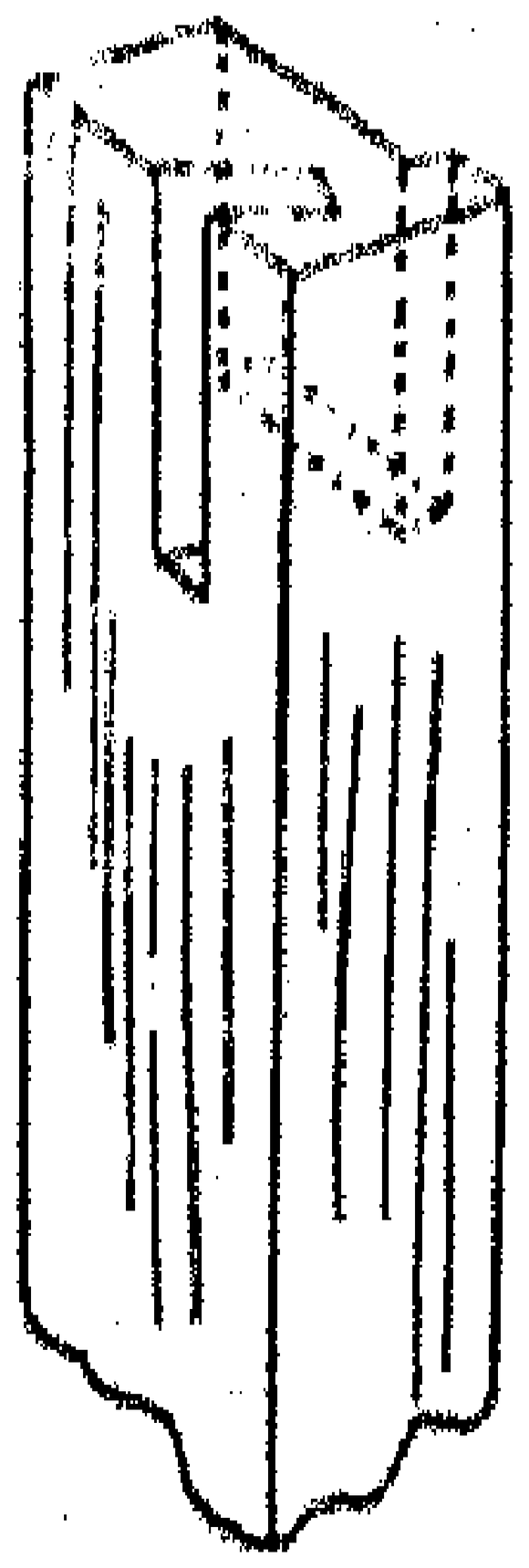


Fig. 3

Fig. 3 shows how the tops of the two front legs are cut to take the side and front rails. The top of the side of the leg which faces the wall is cut out to a depth of 2½ in. and ½ in. wide to a distance of ½ in. from the front. On the opposite face, a ½-in.-wide groove is cut at an angle of 45° to the back of the leg and to the same depth as the back cut, to take the front rail.

An alternative method is shown in Fig. 4, where the top front rail is not laid in an open-ended mortice (as in Fig. 3), but is just recessed for its thickness (½ in.), at an angle in front of the leg. This does not make such a satisfactory joint as the one previously mentioned, but it avoids the necessity of making the open-ended mortice.

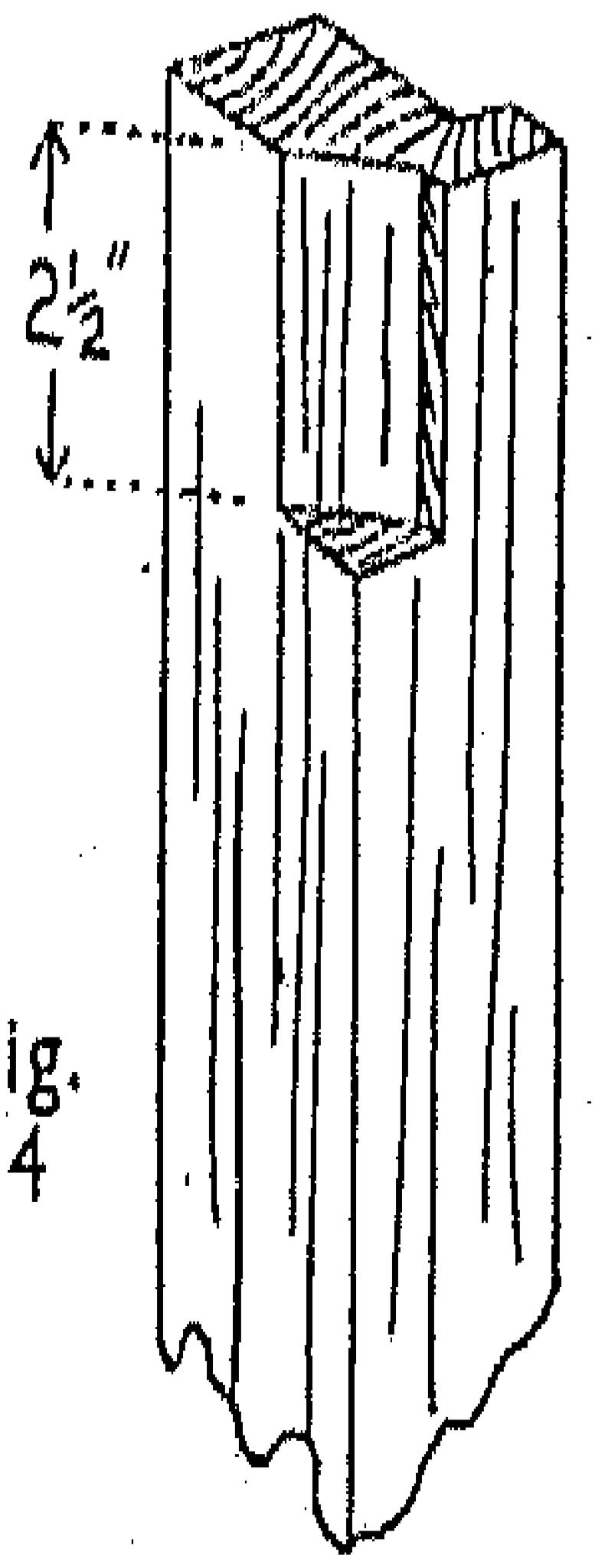


Fig. 4

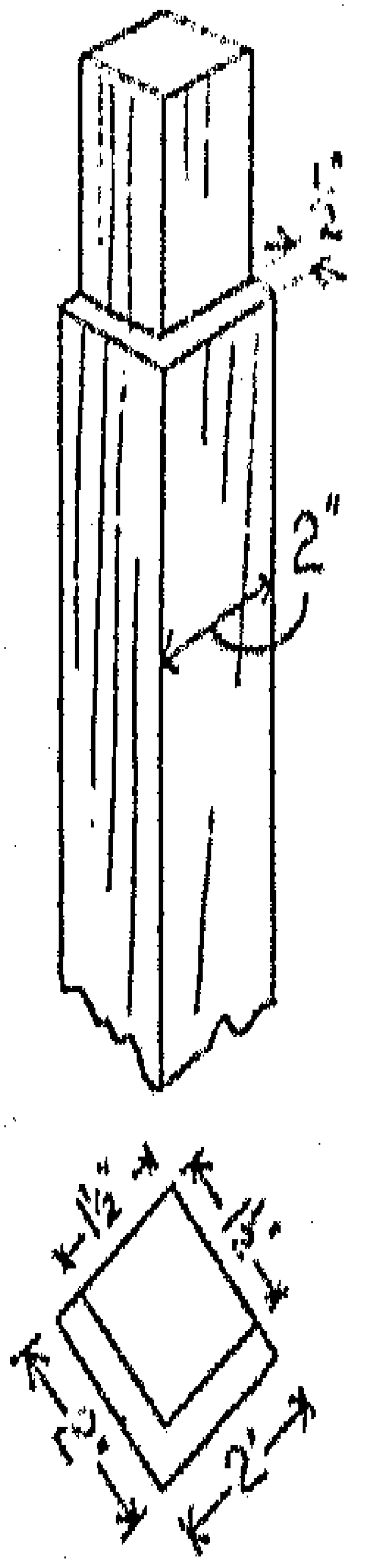


Fig. 5

The left-hand leg will be set out, of course, the other way about.

The back (corner) leg supports the rails on a shoulder formed by sawing down adjacent sides to a depth of 2½ in.—the depth of the rail—and is cut back ½ in. from the face. This is shown in Fig. 5. As the leg is 2 in. square, this leaves an upstanding piece 1½ in. square to which the rails are nailed or screwed.

The bottom rails are housed into the legs at the back, the housing for the front leg being shown in Fig. 6, as viewed from the back. It takes the end of the 2-in. by ½-in. lower rail. The housing or recess should be ½ in. deep and 1 in. long. The rails are housed into the back leg in the same way as that adopted for the top ones.

The housing is made by cutting across the back two adjacent faces of the leg, cutting into each side for ½ in. parallel with the face so that the rail lies snugly in.

The Table-top is cut 1 in. longer each side than the width of the frame. The short sides are 2 ft. 2 in. long. The end is cut square with the wall. The front ends are cut off square with the wall each side, and at 3 in. from the wall, measured square with it.

The top can be screwed down with large screws (3 in. No. 10), driven into the tops of the legs, and thinner ones into the frame. The addition of iron brackets screwed to the legs and underneath the table-top will greatly strengthen the fitment. All joints should be glued and screwed, but if preferred, dowel pins can be used instead of screws.

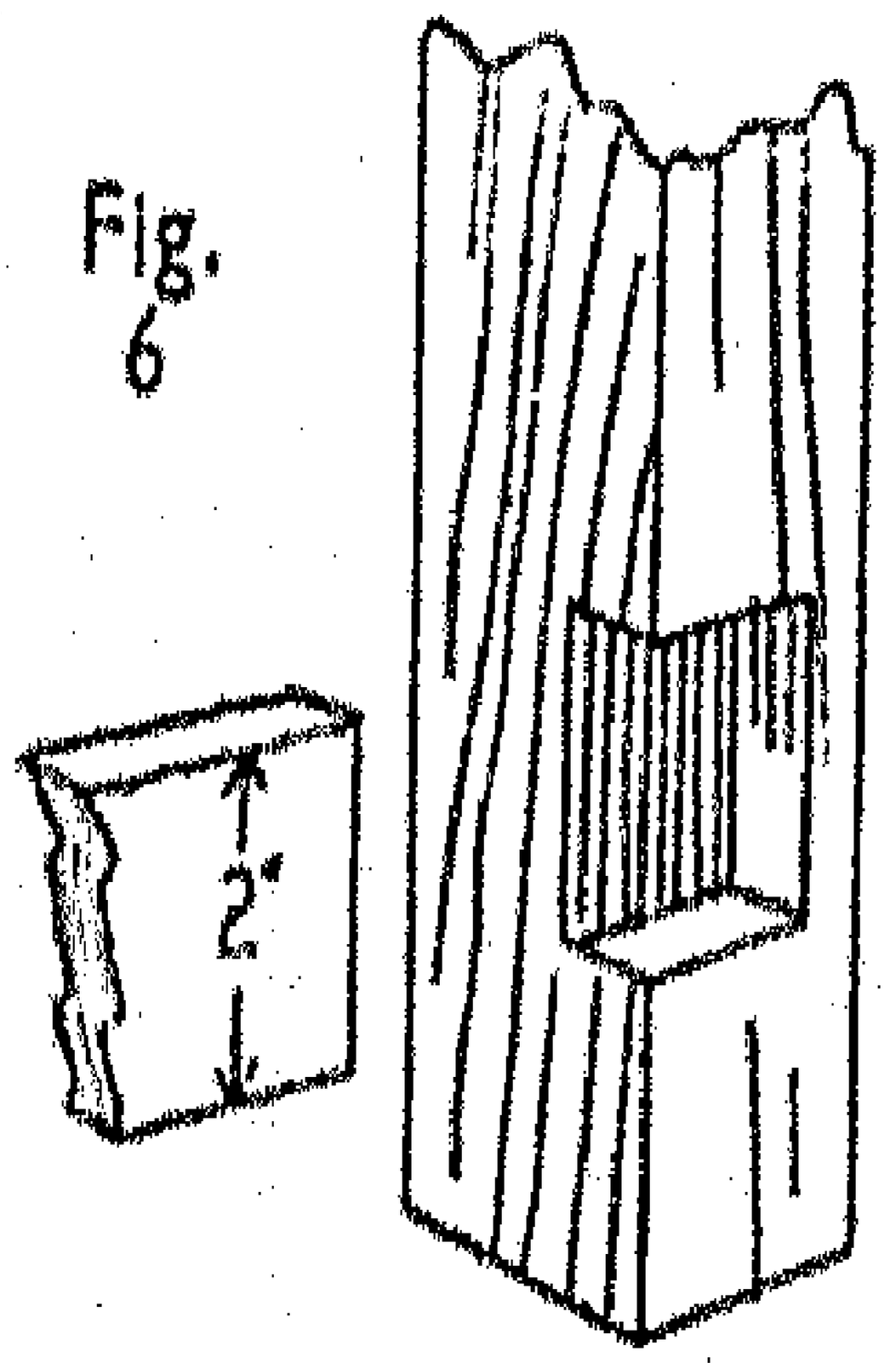


Fig. 6

A MEDICINE CHEST

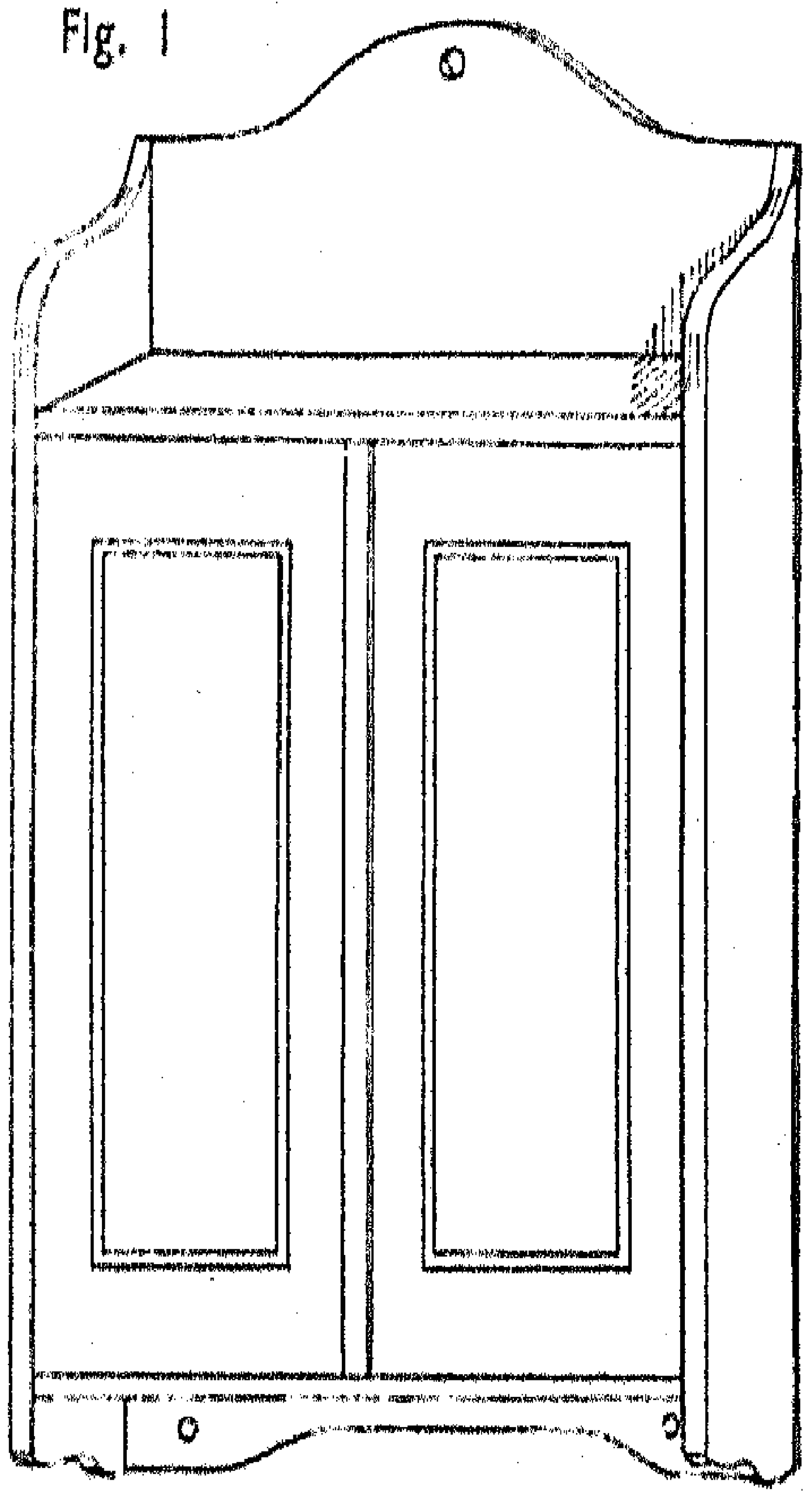
A cabinet for storing ointment, bandages, and other first-aid materials should be included in the fitments of every home. Such a cabinet, the chief parts of which are constructed of whitewood, is represented in Fig. 1, and the working drawings in Working Drawing No. 5.

The Back is in one piece, 14 in. by 18½ in., and ½ in. thick, with the top and bottom edges shaped as shown. A pair of sides, also prepared out of ½ in. thick material, is cut to the shape shown, each piece being 17 in. long by 6½ in. wide. The two grooves for housing the top and bottom of the cabinet may be cut right across the width on the inside faces of the sides as indicated, or, if the joint is not desired to show, the ends of the grooves at the front should be stopped before reaching the front edge, and the top and bottom boards cut to suit, as indicated in the detail. The two boards for the top and bottom members should be prepared first, as it is easier to make the grooves to suit the thickness of these.

Plywood, ¼ in. thick, is used for the horizontal partition between the top compartment and the small drawer, and the sides and back may be grooved for the edges of this. To eliminate the trouble of grooving, a very small fillet could be used under the back edge for supporting the partition, provided the back of the drawer be cut away to clear it, and thus allow the drawer to go back the full distance. Fillets may also be used to support the side edges, behind the two ⅜-in.-wide pieces at the front, at the sides of the drawer. These reduce the opening of this section, so that the drawer will pull out and clear the doors.

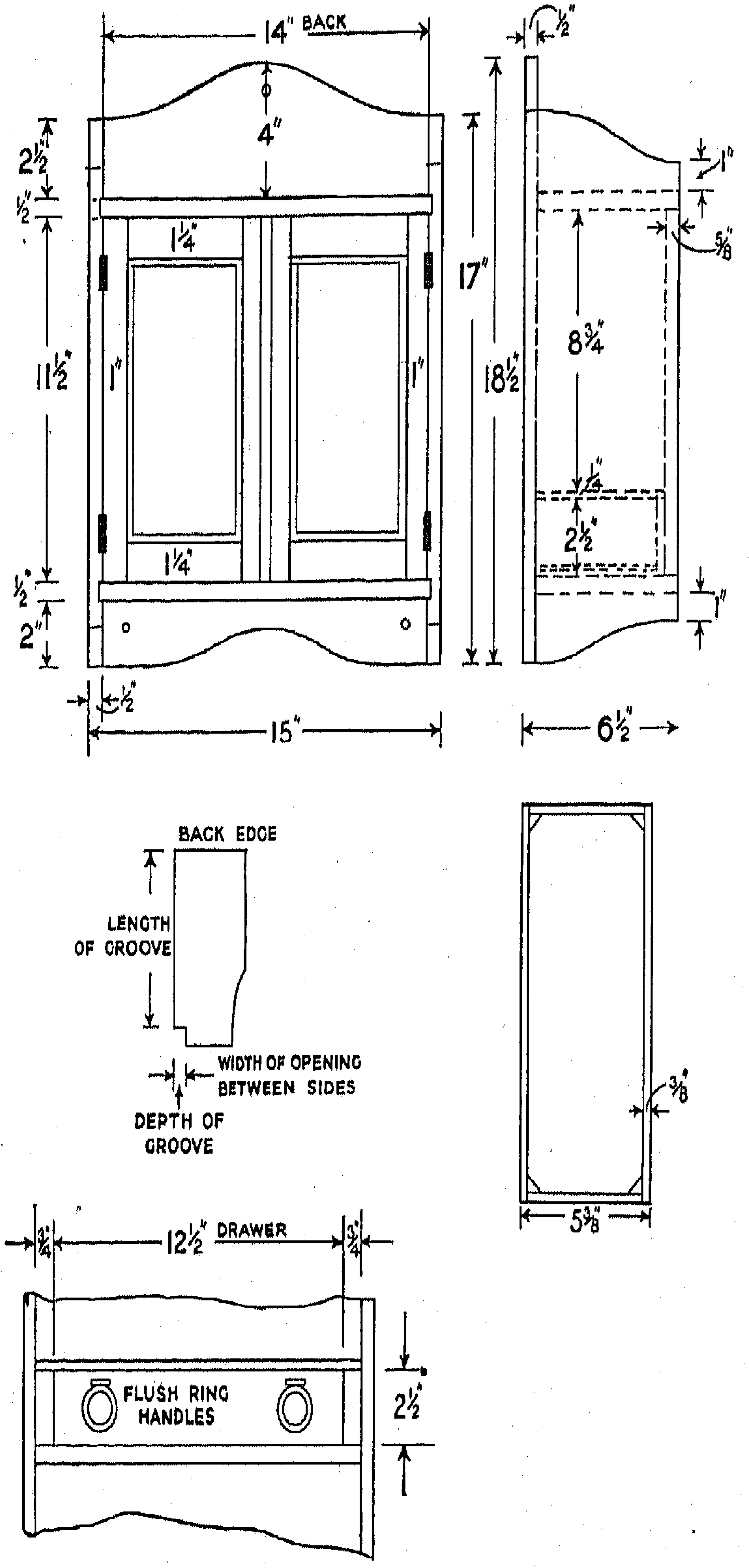
Only a simple drawer is required, as it is used chiefly for storing bandages, etc. The front is 2½ in. wide by 12½ in. long, and ⅜ in. thick, with drop-ring handles let in flush. The sides and back may be about $\frac{3}{16}$ in. thick material, glued and pinned, with corner glue-blocks used. A thin plywood bottom is glued and pinned to a light fillet inside the drawer, and fixed to the front and back.

Fig. 1



One of the twin doors has a narrow length of beading covering the joint to act as a stop, although the drawer will prevent them from going back inwards. The overall thickness of the doors is ⅝ in. and may be built up of ½ in. thick by 1 in. or 1¼ in. wide wood as a frame, with ⅛-in.-thick plywood backing, and a narrow moulding round the edge of the panels on the outside.

Mahogany, walnut or oak stain followed by polish are suitable finishes.



MEDICINE CHEST

WORKING DRAWING No. 5

A USEFUL BOOKCASE

THE bookcase illustrated in the accompanying sketch (Fig. 1) can be of oak, walnut, mahogany, or even whitewood. If oak is chosen it can be "limed" in accordance with the latest fashion or it may be wax polished. Walnut and mahogany, of course, need french polishing to bring out the natural beauties of the wood. In cases where whitewood is employed, it may be stained and varnished to imitate more expensive woods.

By referring to the detailed drawings it will be seen that the principal members are the two sides and the top and bottom boards. The sides are of ¾-in. material and the bottom and top of 1-in.

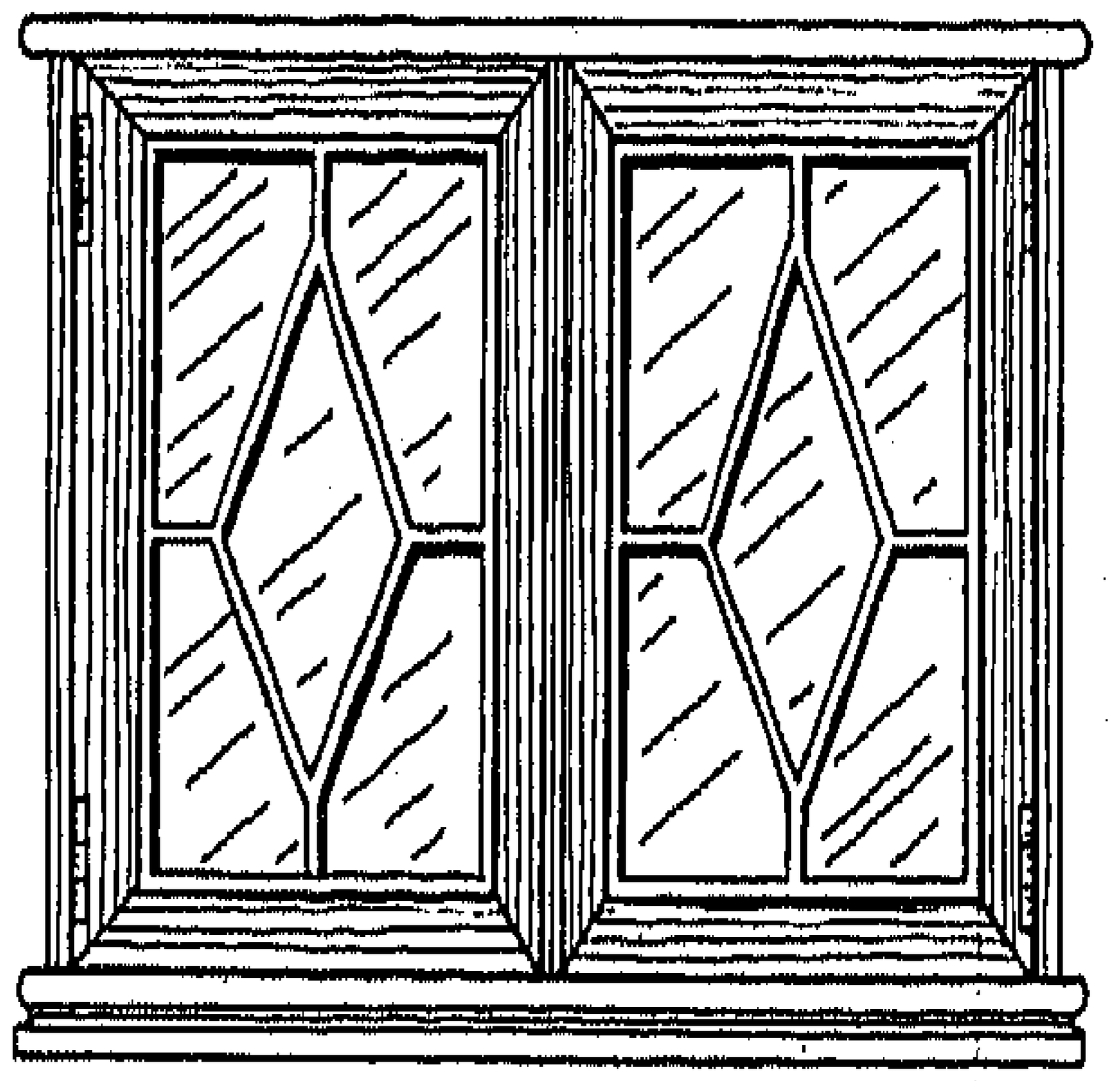


Fig. 1

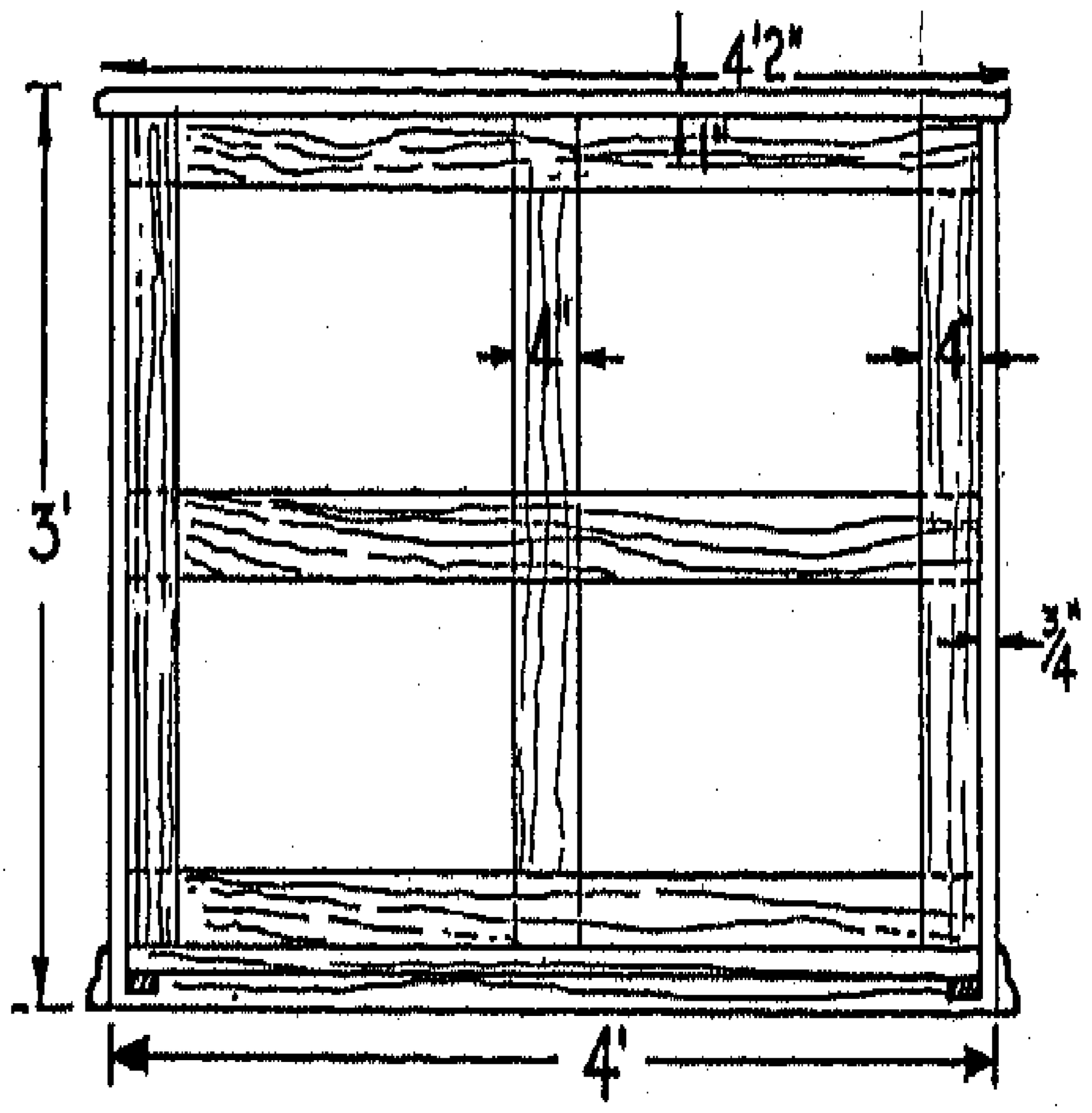


Fig. 2

There is no need to use an expensive wood for the bottom member, as it is hidden, its edges being concealed by a moulding. Ordinary yellow deal can be used for this.

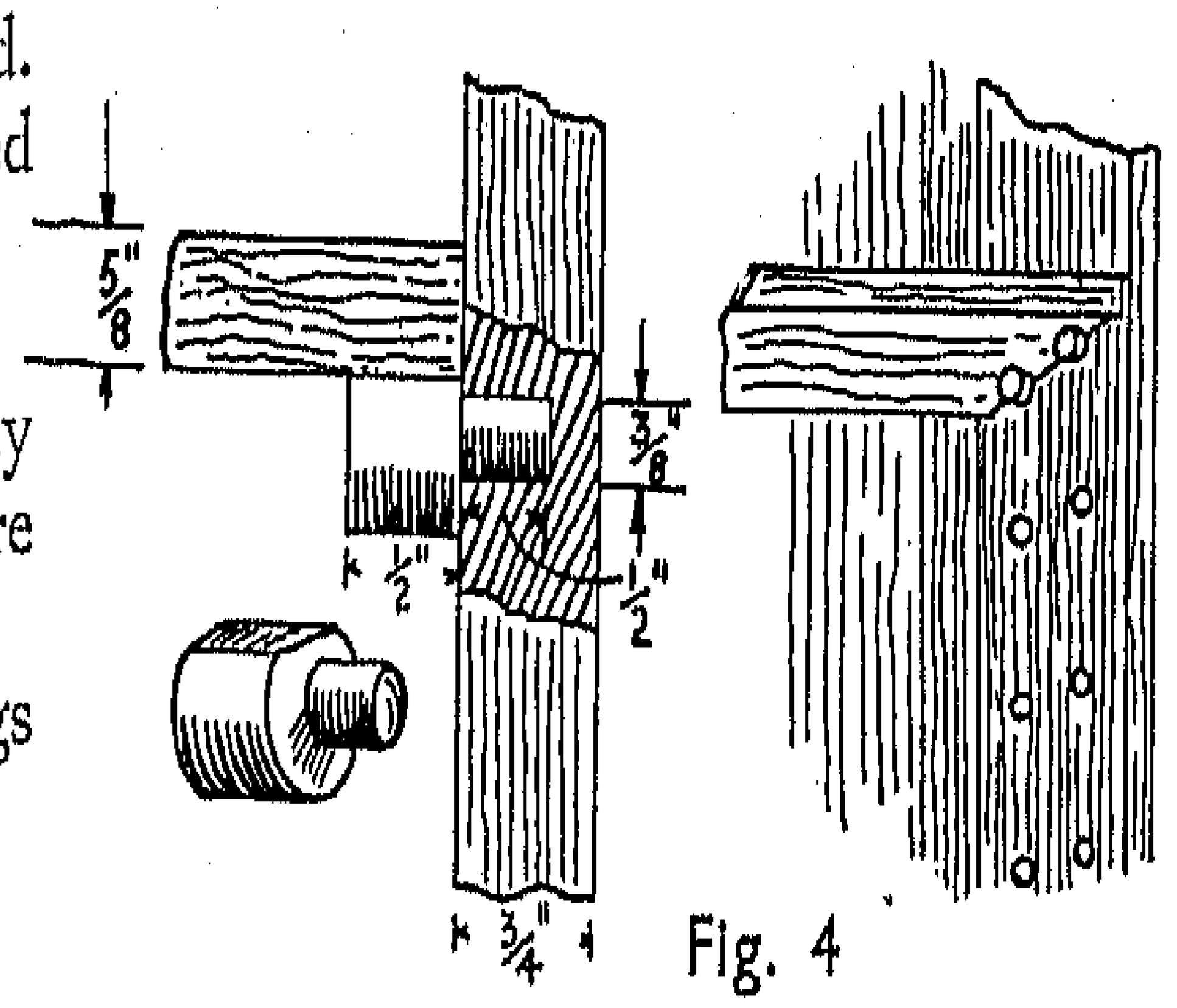


Fig. 4

The first thing to do is to prepare the parts for the carcass. Carefully mark, saw and plane up the top member to an overall size of 4 ft. 2 in. long and 1 ft. 2 in. wide. Plane the back edge perfectly square, and round off the front and end ones. Next prepare the bottom board and the sides. The former is 3 ft. 10½ in. in length by 11 in. wide and the latter 2 ft. 11 in. by 11 in.

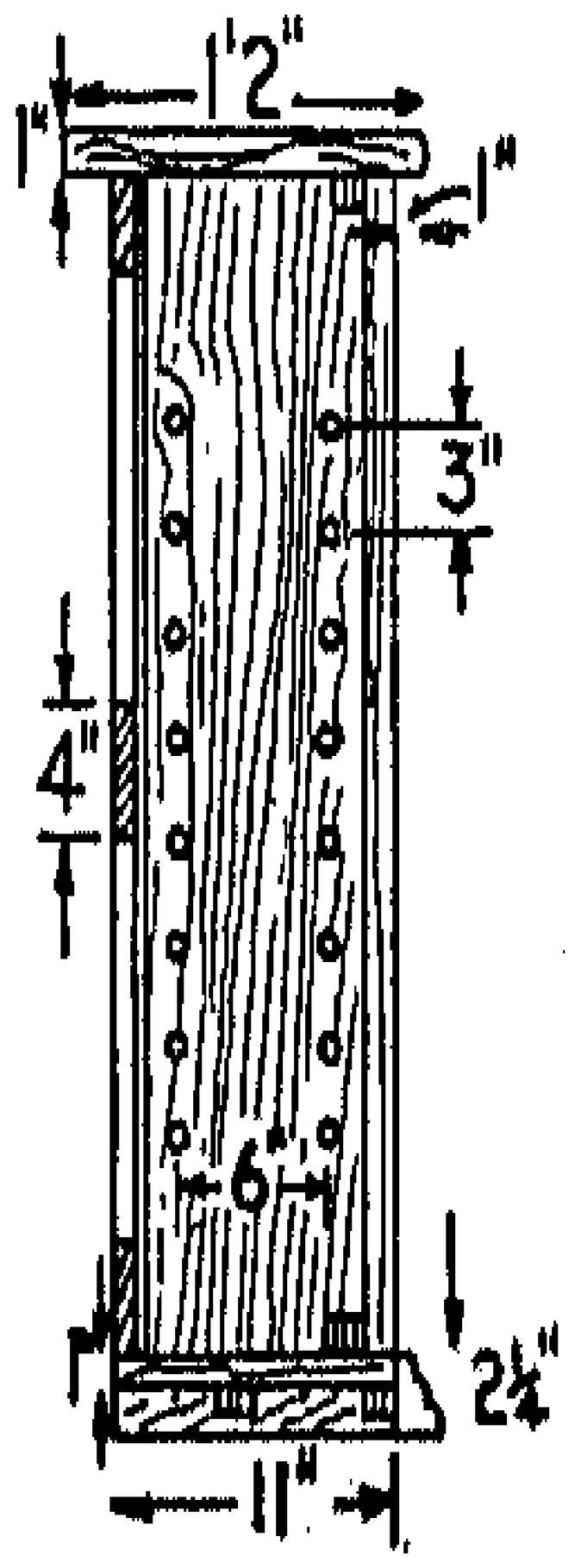


Fig. 3

Mark out the positions for the holes on the inside faces of the end members as shown in Fig. 3. The holes are for the plug supports which keep the shelves in position, details of which are given in Fig. 4. Eight rows of holes are necessary, which allow a considerable variation of shelf positions to be made, to suit books of various heights. The holes are spaced 6 in. apart horizontally, and 3 in. apart vertically. They should be bored to a depth of ½ in., using a sharp ⅜-in. diameter centre-bit for the purpose. Great care must be taken when making the holes to prevent the point of the bit penetrating the outer face.

The Back consists of a framing made of 4 in. by ½ in. deal, with a vertical and a horizontal cross-member of the same size, as illustrated in Fig. 2. The parts are halved into each other and firmly held with screws. The frame is then faced inside with a sheet of plywood, which, when fixed into the back of the carcass, rigidly supports the whole of the structure. The size of the frame is 3 ft. 10½ in. long and 2 ft. 8¾ in. high.

The parts should now be carefully assembled with the aid of screws.

The top face of the bottom board is fixed to the sides at a distance of 2¼ in. above the bottom edges, while the top board projects 1 in. over the front and sides and 2 in. at the back—the latter to fill the space occupied by the skirting board of the room and thus allow the top back edge to butt against the wall.

The Top Board should be screwed down firmly to the sides, the countersunk heads being covered, at a later stage, with a coloured filling to match the finish.

The built-up back should be driven in flush with the back inner edges of the carcass and fixed either by nails driven through at an angle from the back, or by means of long, oval brads driven in through the side members. If the latter method is adopted, the heads of the brads should be punched well below the surface and the holes filled in with stopping.

Fig. 2 shows how the frame, minus the plywood facing, fits in the back of the carcass, while the panel is shown distinctly in Fig. 3.

The carcass is complete when a suitable plinth moulding of any standard section has been sawn to length, mitred at the corners and fixed around the base.

The doors are framed and constructed of suitable material 4 in. wide and ¾ in. thick. The joint used is a combination of a mitred and a halved joint, which is not only exceptionally strong, but obviates the making of mortices and tenons.

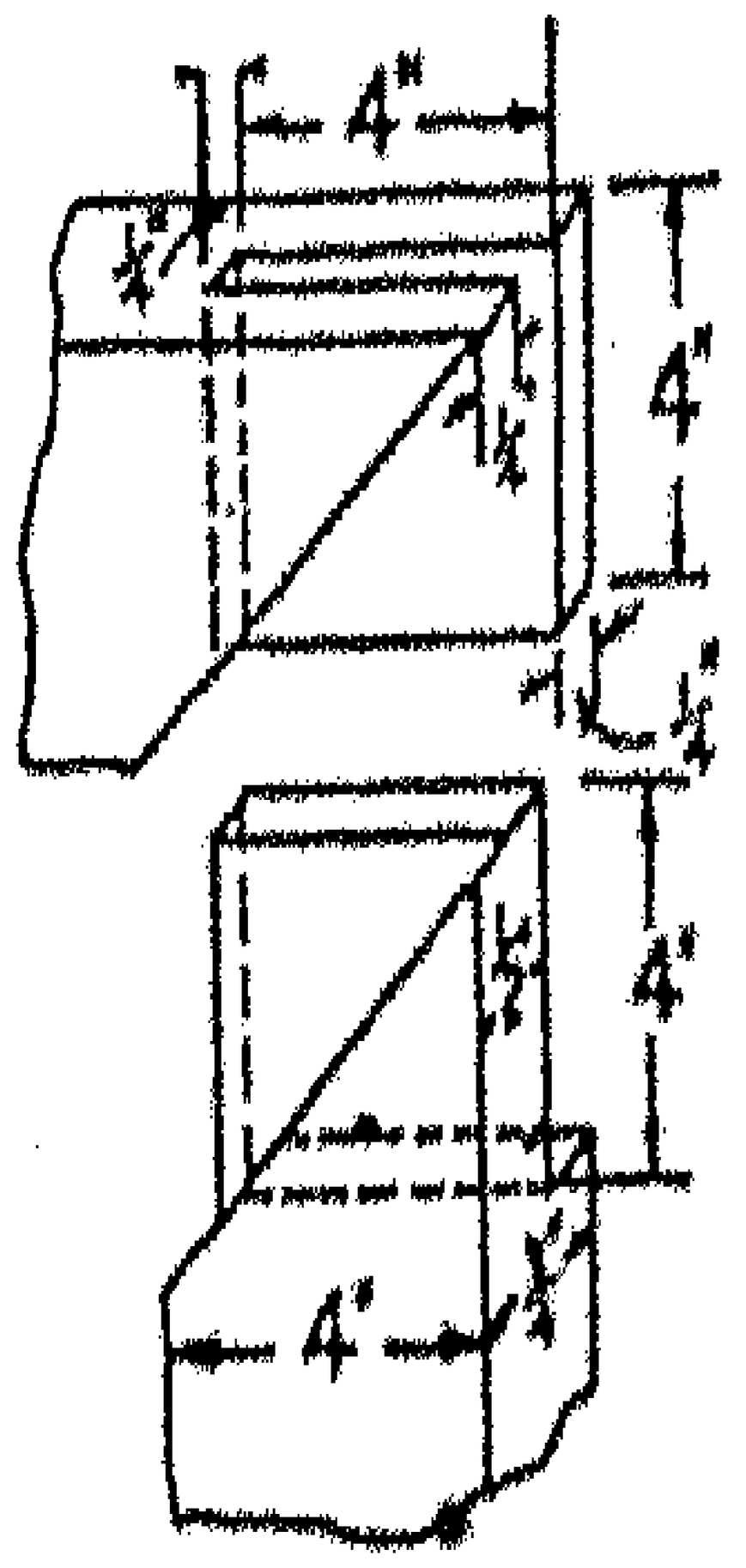


Fig. 5

To make the Frames, proceed in the following manner:

First cut the members a trifle longer than the finished sizes of the doors, which are 1 ft. 11¼ in. wide and 2 ft. 8¾ in. high. At the ends of the rails or cross members, scribe down two lines parallel to the wide face and ¼ in. from the edge, leaving a central space ¼ in. wide, i.e. dividing the ends into three thicknesses. Saw down these lines to a depth of 4 in. from the end, and cut the centre piece out with a chisel. Take a bevel-square and scribe the 45° angle on the front and saw through. The end of the rail with the prepared joint is shown in Fig. 5.

The ends of the stiles or side members are marked off in a similar way and sawn down at the back to a depth of 4 in. They are then cut squarely across as indicated in Fig. 5. The front face is marked for the mitre as before and sawn to a depth of ¼ in. on this line, and then sawn down from the end to meet it, thus leaving an upstanding flat piece with a halved back to join with the end of the top rail, and a tongue to fit behind the mitre. The mitre in front fits up against the mitre of the top rail.

This gives a very satisfactory joint. Viewed from the front it looks exactly like an ordinary mitred joint, but it has also the great advantage of having plenty of surface for gluing. The joints can be further strengthened if desired by means of brass screws driven in from the back.

Having completed the joints, they should be cramped after gluing until the glue has set perfectly hard, after which the faces should be lightly skimmed with a sharp, finely-set plane. The outer edges of the doors should also be planed to fit nicely when placed side by side in the front of the carcass.

The Glass.—A ⅜-in.-wide fillet or bead should be cut, mitred, and fixed flush with the back edge inside each frame to hold the glass. A corresponding bead with rounded nose is placed in front of the glass and fixed in position with fine panel pins.

The front of the glass may be left plain or it may be decorated in the manner shown in the illustration (Fig. 1). The design can be built up of hardwood beading. The pieces forming the diamond pattern, struts, and outside beading must be jointed to fit each other, and then glued and pinned.

A simple way to do this is to cut a thin plywood panel exactly to fit the opening in the frame. The outline of the design is then traced on the panel. The parts are then cut to coincide with the design and pinned temporarily in position whilst being fitted. The pieces should be very carefully cut to the set-out angles to ensure a perfectly tight fit. Having prepared the parts, glue and pin them together and, when dry, stain and finish them to the colour and finish with either polish or varnish. The clean glass is then inserted into the frame and the ornamented overlay fixed to the glass with tube glue, the outside beading being fixed by means of very fine panel pins.

The doors should be hung with brass butts.

The left-hand door is prevented from closing inwards by means of hardwood stops, while the right-hand one has a ¼-in.-wide beading projecting ¼ in. beyond its long opening edge, which acts as a stop against the left-hand door. A couple of sliding bolts should be fitted to the inside face of the left-hand door and a lock and escutcheon fixed in the centre of the opening stile of the other.

The final operation—except finishing—consists in cutting and fitting the desired number of shelves.

A SECTIONAL BOOKCASE

An expanding or sectional bookcase is a particularly convenient means of storing books. The construction of such a bookcase is a matter of simple carpentry and can be made by any handyman by following the detailed drawings on Working Drawing No. 6, to which all figure numbers appearing in the following paragraphs refer.

Fig. 1 shows a drawing of three complete units, identical in size, supported upon a base, and a top section to give the assembly a neat finish. The depth of each book unit is 1 ft., but this is an arbitrary measurement and sections can be built higher or lower as the case may be, keeping all the other dimensions the same. Since the ends are quite flat, additional units can be laid lengthways against each other so that the bookcase can be expanded sideways as well.

Fig. 2 shows the complete unit without its doors. The doors shown in Fig. 11 are hinged at the sides and close together in the centre. An alternative arrangement is to have one door hinged from the top. This would make no difference to the general construction of the bookcase.

Fig. 3 shows the front of a standard book unit; Fig. 4, a transverse section, and Fig. 5 an end view. The top or covering unit is shown in Figs. 6, 7 and 8, and the base in Figs. 9 and 10, while Figs. 11 and 12 show details of the doors. All drawings are fully dimensioned.

The Sides are of one piece of wood 1 ft. high and 10¾ in. wide. They are joined by the bottom board (or shelf) 2 ft. 6 in. long and 10 in. wide, which should be fixed by means of screws driven through the sides, using four long screws for the purpose. The bottom of the shelf is ½ in. above the bottom edges of the sides and forms the location for the member underneath; whether it be another book unit, top section or base. The back—partly visible in Fig 3, which is a front view—consists of a frame made of 2-in. planed batten ¾ in. thick, halved at the four corners, and to it is pinned a three-ply panel 10 in. wide and 2 ft. 6 in. long. This panel fits exactly into the back, between the top back rail and the shelf, completely filling the inside of the back member as seen in Fig. 4.

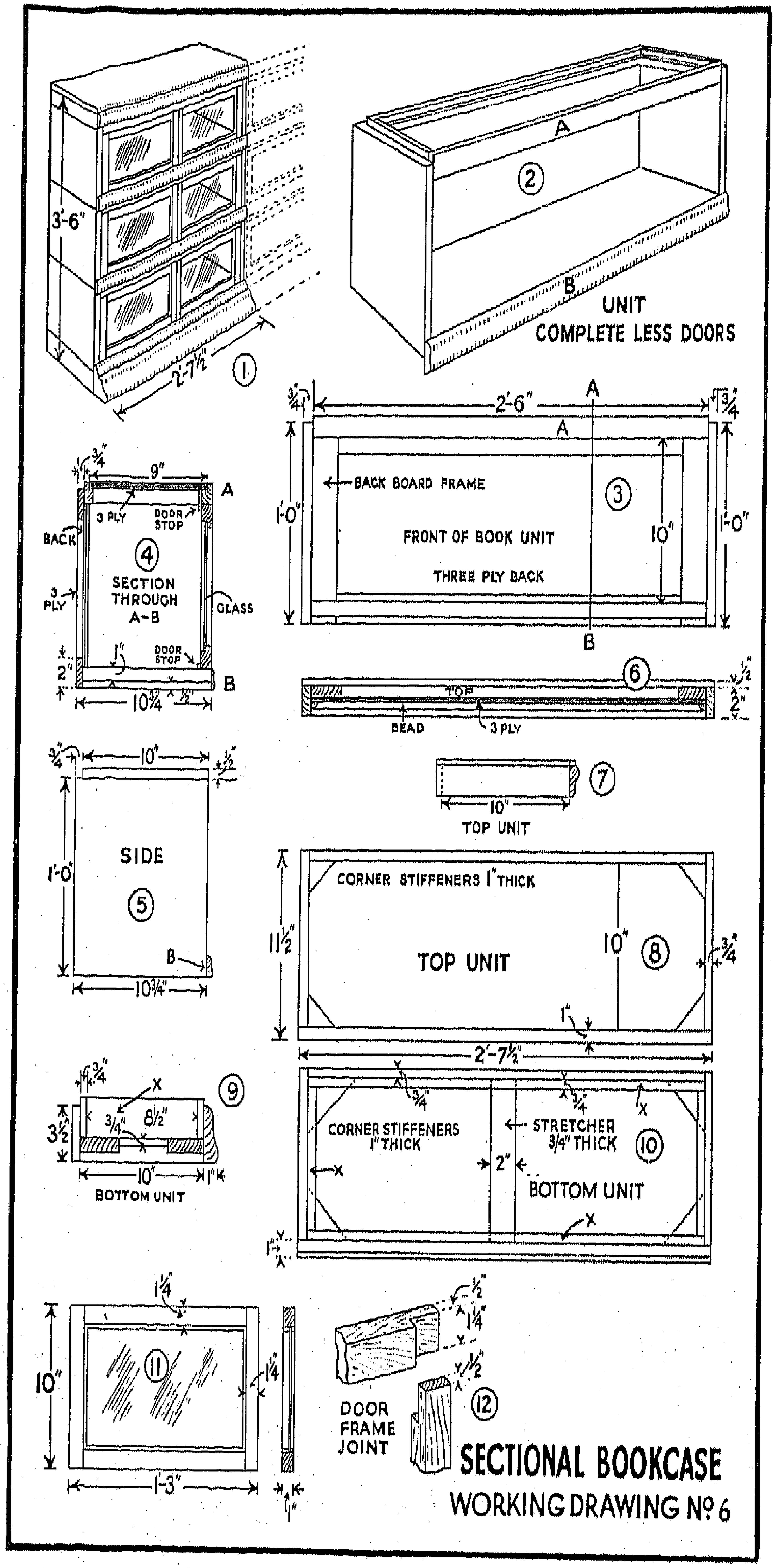
Looking at Fig. 2 at A, it will be seen that the facia board projects ½ in. above the tops of the sides, and around the inside faces at the top is a rebated rail. This arrangement at the back and sides provides the location of the upper unit, whether it be for a top covering section or a book unit. The recess also provides a means of support for a plywood panel to keep out the dust, so that each unit is quite dustproof. The front of the unit is flush except for the moulding B, which is fitted along the whole length of the front edge of the shelf and extends ½ in. below it, thus registering with the bottom of the end board or side.

The bottoms of the sides, moulding and the back board frame form a recess ½ in. deep into which the top of the unit below exactly fits. The moulding B should be glued and pinned to the edge of the shelf and the sides, using fine panel pins for the purpose. This completes the book unit.

The top covering section illustrated at Figs. 6, 7 and 8 is a frame of ¾-in. stuff, 2 in. deep round the sides and back, the front being a moulding. The moulding extends down a further ½ in. to register on the front of the facia rail A of the book unit. Fig. 8 gives a plan and top view with the covering board removed, and shows the corner stiffeners which should be glued and nailed in.

A plywood panel may be inserted and fixed to the bottoms of the corner pieces and the joint so formed covered with a ¼-in. quarter-round bead, to prevent the somewhat unsightly inside showing when the doors are open. The top board is a plain piece of ½-in. wood with a rounded front edge, the remaining edges being left square. The rounded edge imparts a neat finish when the bookcase is small and comparatively low in height.

The Bottom Unit or base is built up, as shown in the cross section (Fig. 9), to the dimensions given in the plan view (Fig. 10). The front member is a moulding, and the moulding B of the book unit rests on it and makes an attractive finish. The corners are strengthened by means of angle blocks 1 in. thick, which should be glued and screwed from the inside, while a brace 2 in. wide and ¾ in. thick is fixed across the middle to the undersides of the raised lining X (Figs. 9 and 10). The lining—made of ¾-in. stuff—beds down



SECTIONAL BOOKCASE
WORKING DRAWING Nº 6

on the corner pieces and is nailed through the inside into the frame and stands up ½ in. above it to fit inside the under frame of the unit above.

All the joints can be nailed if desired, but a very much better result is obtained by fixing the members together by means of screws. The member requiring the most care in fixing is the facia rail A, as it has not much contact with the ends. It is therefore advisable to reinforce this piece by means of a couple of small right-angle metal brackets fixed inside with screws.

Each Door consists of a frame 1¼ in. wide and 1 in. thick, details of which appear in Fig. 11. The outside edges of the frame should be made 1/16 in. over the dimensions shown to allow for fitting. The corner joints, details of which appear in Fig. 12, are plain halved ones which should be carefully made and accurately fitted. It is an advantage to glue and fasten the joints together with brass screws driven in from the back, care being taken to sink the heads below the level of the surface. The resulting depressions can be filled in afterwards with plastic wood. A sharp, finely-set plane should be run over the surfaces after the glue has set to ensure a perfectly smooth finish.

Each door is hung on two brass butt hinges. The leaves of the hinges should be sunk into recesses cut into the edge of the door and the inside edge of the side. A stop is necessary at the top and bottom, as shown in Fig. 4. The bottom stop can be of hardwood of ½ in. square section, glued and pinned to the shelf board. The top stop should be of the same material 1 in. wide and 2 ft. 6 in. long, with recesses cut at the ends to receive the ends of the inner frame. This is fixed with screws to the inside face of the facia rail A. A piece of half-round beading should be fixed to one edge of each pair of doors to prevent dust entering the interior.

One door, preferably the left-hand one, should have bolts fixed on the inside face at the top and bottom of the opening stile; while the adjacent stile should be fitted with a lock, or a spring ball socket fitment let into the top and bottom edges of the stiles may be used if locking-up is not considered necessary or desired.

The Glass should be of good quality and fairly thick. It should not fit tightly within the frame and it should bed against a round-edged bead 5/16 in. wide by ¼ in. thick, fixed to the inside edges of the frame, with the nose of the rounding flush with the front surface of the door or a trifle in front of it. The corners of the beading should be close-mitred and glued and pinned to the inside faces of the door framing. A corresponding bead at the back of the glass will make all secure and give a neat finish to both sides.

A Door with Mitred Corners can be substituted if desired. It may consist of rebated material and may be nailed and glued as in making a picture-frame, but owing to the unsupported weight of the door when open, it is better not to rely upon the mitred joint alone but to inlay a brass plate across the joint at the back and secure it tightly with brass screws. As regards material, it is better left to the discretion of the maker. Quite a presentable job can be made by using deal for the general construction and either oak or walnut for the door frames and the front mouldings between the units and the base.

If this method is adopted, a good finish can be obtained by staining the common wood to match the better kind, and finish with shellac varnish or french polish applied with a very soft brush.

In the event of a single door being preferred to double ones, the door may

be hinged at the top or bottom. The latter is preferred by some, but there is a greater chance of breaking the glass. Such a door can be made in the same manner as those already described and using any of the joints suggested. It has less diagonal strain than a door hung vertically. A door hung from the facia rail has a distinct advantage over one suspended from the bottom one because in the latter case the moulding below the shelf would catch it and force the hinges if allowed to fall down beyond the horizontal position. In addition, it is awkward to withdraw a book from the case without injury, since the edge of the door rises its own width above the level of the shelf. Furthermore, the books must be lifted to withdraw them—another rather serious disadvantage.

A BUREAU WRITING-DESK

A CONVENIENT knee-hole writing-desk can be constructed from the simple design illustrated in the sketch and the working diagrams shown in Working Drawing No. 7.

It is of a size that will go into the usual recess at the side of a chimney-breast and yet has ample table and leg room—two necessary requirements sometimes overlooked.

The perspective sketch which appears in Fig. 1 shows the appearance of the desk in its open position. The pigeon-hole arrangement shown here can be easily modified to suit the taste of the user, and an alternative scheme is shown in Fig. 2 in the working drawings.

The Best Material to Use for its construction is oak, although a cheaper wood, such as whitewood, stained and brush-polished will make a presentable and durable piece of furniture.

Start by preparing the sides to the dimensions and shapes given in the diagram (Fig. 5). Two pieces of timber ¾ in. thick will be required, unless a board 18 in. wide can be obtained, which will be by far the best arrangement. But failing this, the edges of two boards, 9 in. wide, may be accurately planed and glued together to form a glued butt joint. The joint will then come below the top board of the desk and not in the slant upon which the lid lies when the desk is closed.

The Back can be built up of a cross framing and plywood, as described in the article dealing with the bookcase. The framing will be 3 ft. 4½ in. long and 3 ft. 2 in. deep and should be nailed in from the side boards and from the top board.

The Top of the desk is a board 10 in. wide and ¾ in. thick. Its front edge should be bevelled to the angle of the flap when closed, as the flap beds up against it, as will be described later. The top projects ½ in. beyond the sides and back and should have rounded edges at the ends and back to give it a neat finish. The front edge is shown clearly in Fig. 3.

The overall dimensions of the fixed desk-board are 3 ft. 4½ in. long and 1 ft. 6 in. wide, and it is fitted horizontally between the side-members at a distance of 2 ft. 3 in. from the floor level. It is constructed of two boards in the same manner as that employed for the sides. The board should be screwed in from the sides with long countersunk-headed screws and the tops of the screw-holes filled with a good kind of wood-filler, such as plastic wood. With the top, back and desk-board in position we have a solid framing and can begin to fill in the details.

At 1 ft. $3\frac{3}{4}$ in. from the inside face of the right-hand end is a division or partition extending from the desk-board to the floor level. It is of $\frac{3}{4}$-in. stuff, comes flush with the edge of the desk-board and the side-members, and joins the framed backboard at the back. The size of the partition is 2 ft. $2\frac{1}{4}$ in. high and 1 ft. $5\frac{1}{4}$ in. wide. It can be fixed by driving four $2\frac{1}{2}$-in. oval brads through the desk-board into the top edge and by brads driven in from the back. The heads of the nails should be sunk below the surface and the holes filled in with plastic wood.

Two shelves, 1 ft. 2 in. deep and 1 ft. $3\frac{3}{4}$ in. long, are fitted between the partition and the right-hand side-member, while a footboard 2 ft. long and 1 ft. $5\frac{1}{4}$ in. deep is fixed on the other side. The latter may be fixed in any position convenient to the user. The shelves and footboard are fixed by driving brads through the partition and the side-members.

At the left of what may be termed the central board is a slide-box, its purpose being to house the slide that supports the flap. It is made of $\frac{3}{4}$-in. stuff and fixed to the underside of the desk-board by means of screws driven in from the top and by nails driven through the partition.

The Outside Member of the box is spaced 1 in. from the side of the central board and is $5\frac{3}{4}$ in. wide. The base of the box is a strip of wood $\frac{3}{4}$ in. thick and 1 in. wide.

The slide is 1 in. thick, 5 in. wide and 1 ft. 5 in. long and is shown in the side view in Fig. 3. It should be a nice fit, for it is to support, nearly at its centre, the desk flap which forms the writing-table portion of the desk.

A $3\frac{1}{2}$-in. by $\frac{3}{4}$-in. rail is nailed between the slide-box and the left-hand side of the desk. It could be replaced by a drawer if desired. The object of the rail is to give the desk-board solidity and improve the appearance when the desk is closed by having a surface below the sloping flap to correspond with the front plane of the cupboard door.

The Footboard is nailed across the knee-hole at a distance of 2 in. from the floor and is supported by a front rail, as shown. This rail is 2 in. wide and $\frac{3}{4}$ in. thick and has a curved recess cut in the bottom for the sake of appearance. The footboard is constructed by gluing the long edges of two boards together, or the boards may be braced together by means of battens fixed across the undersides.

The footboard is supported on 2-in. by $\frac{3}{4}$-in. planed battens, screwed to the inside face of the left side-member and the left-hand face of the central board, and is held securely in position with screws driven through near the top edges. This cross-screwing greatly assists in strengthening the desk against distortion when moving it.

The Cupboard Door fits inside the cupboard and consists of two boards glued and butted together and further strengthened with cross-battens screwed on from the back. The cross-pieces should be about $1\frac{3}{4}$ in. wide and $\frac{3}{4}$ in. thick and fitted at a distance of about 3 in. from the top and bottom edges of the door. The overall dimensions of the door are 2 ft. $1\frac{1}{2}$ in. high and 1 ft. $3\frac{3}{4}$ in. wide. It should be fitted with a suitable lock.

The desk-flap should be made of one piece of perfectly flat and well-seasoned timber. Its length is the full width of the desk, i.e. 3 ft. 6 in., and its width 1 ft. 3 in. The edges should be rounded, as shown in Figs. 2 and 3, and it should be hinged to the desk-board by two brass flap-hinges let into the desk-board

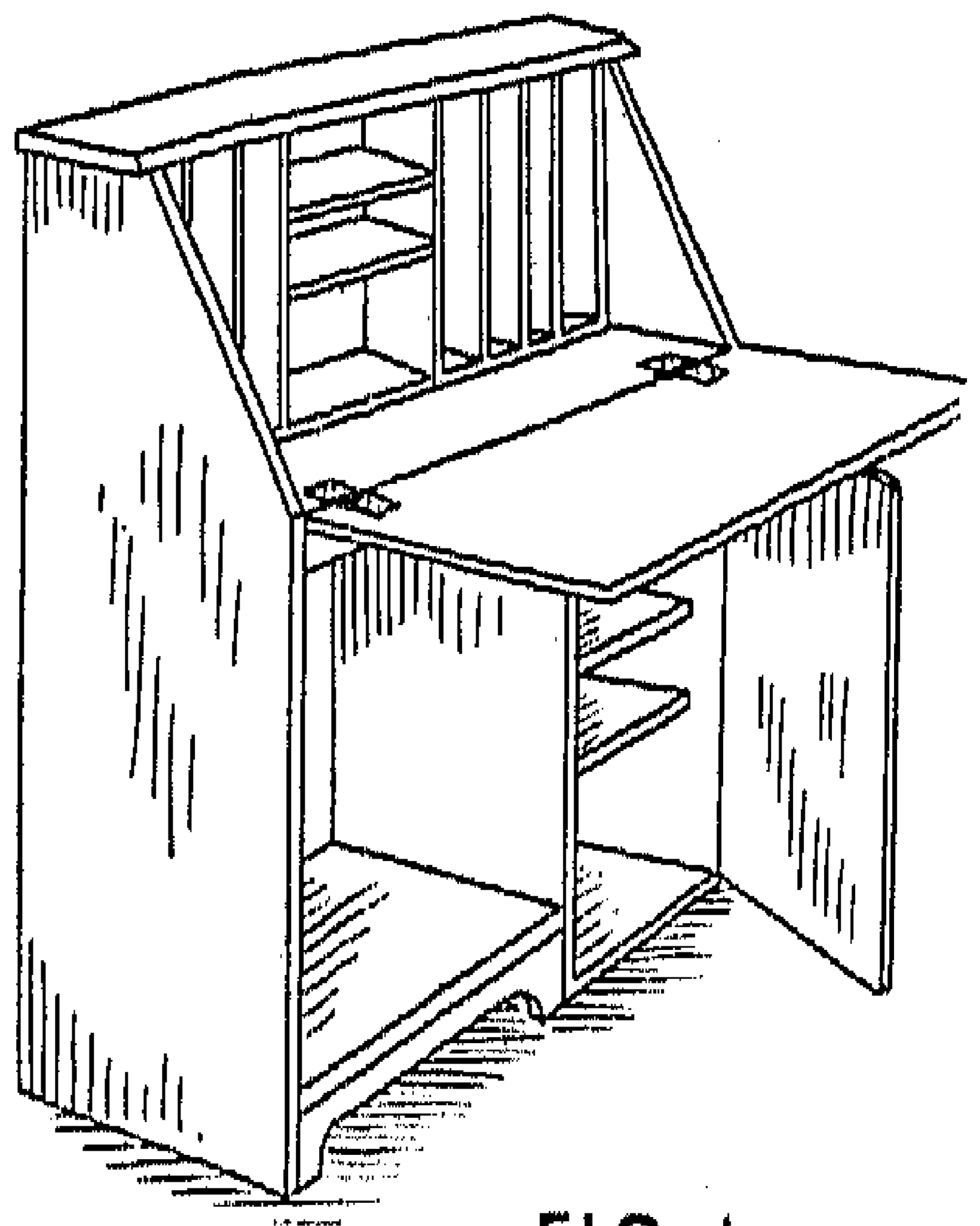


FIG. 1

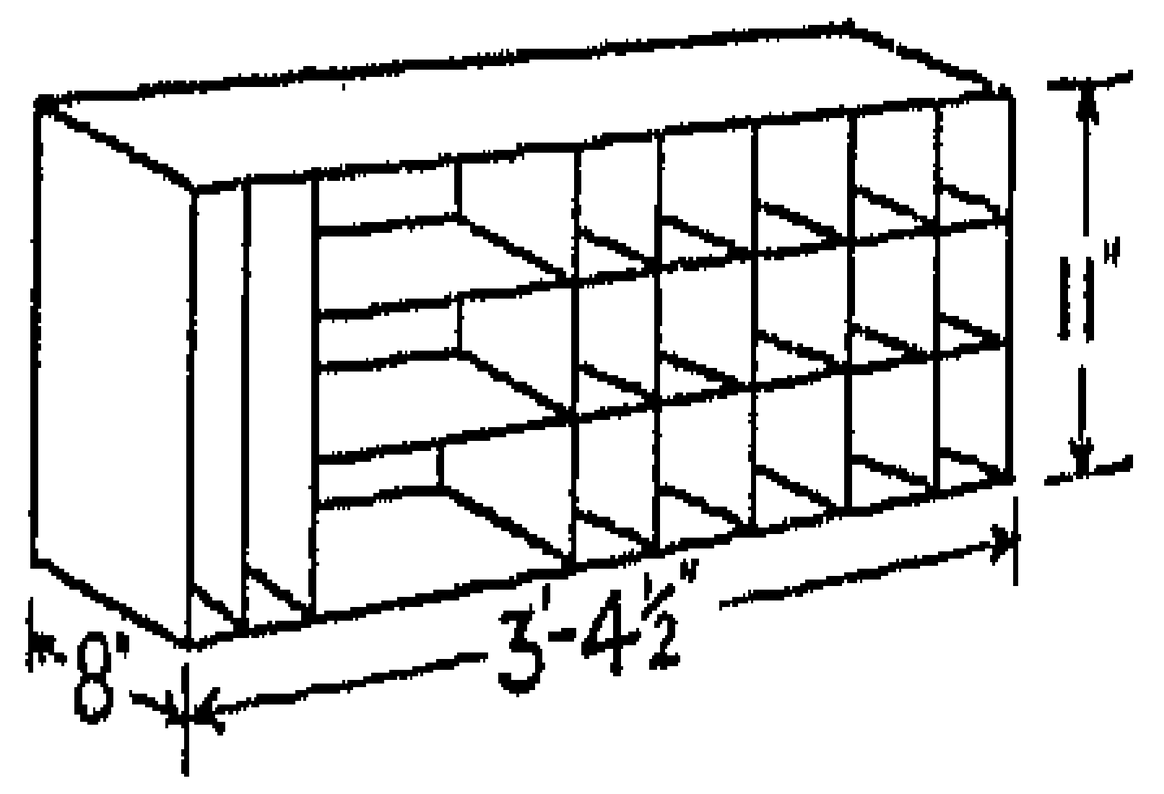


FIG. 4

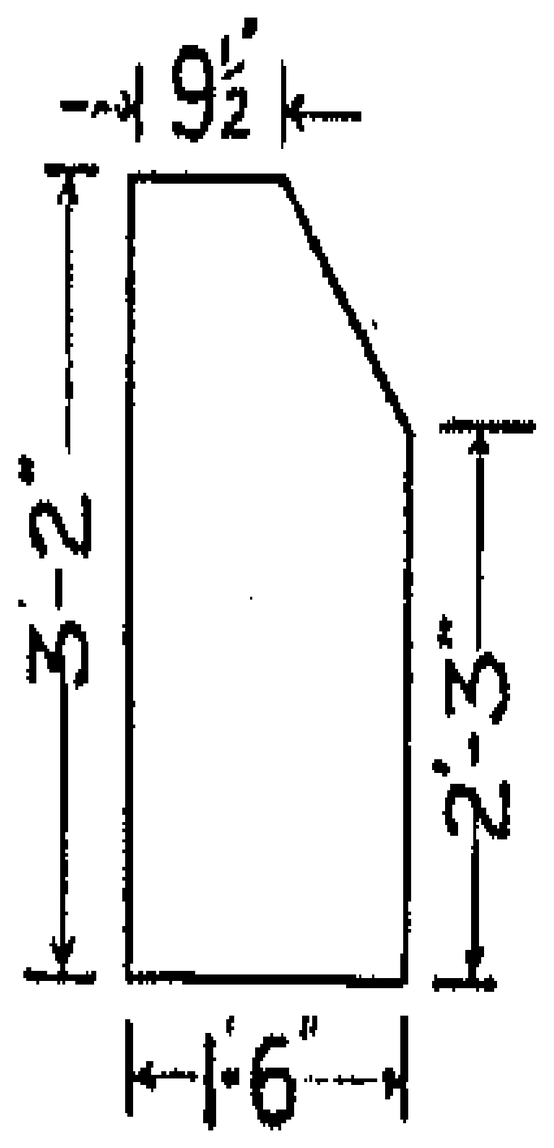
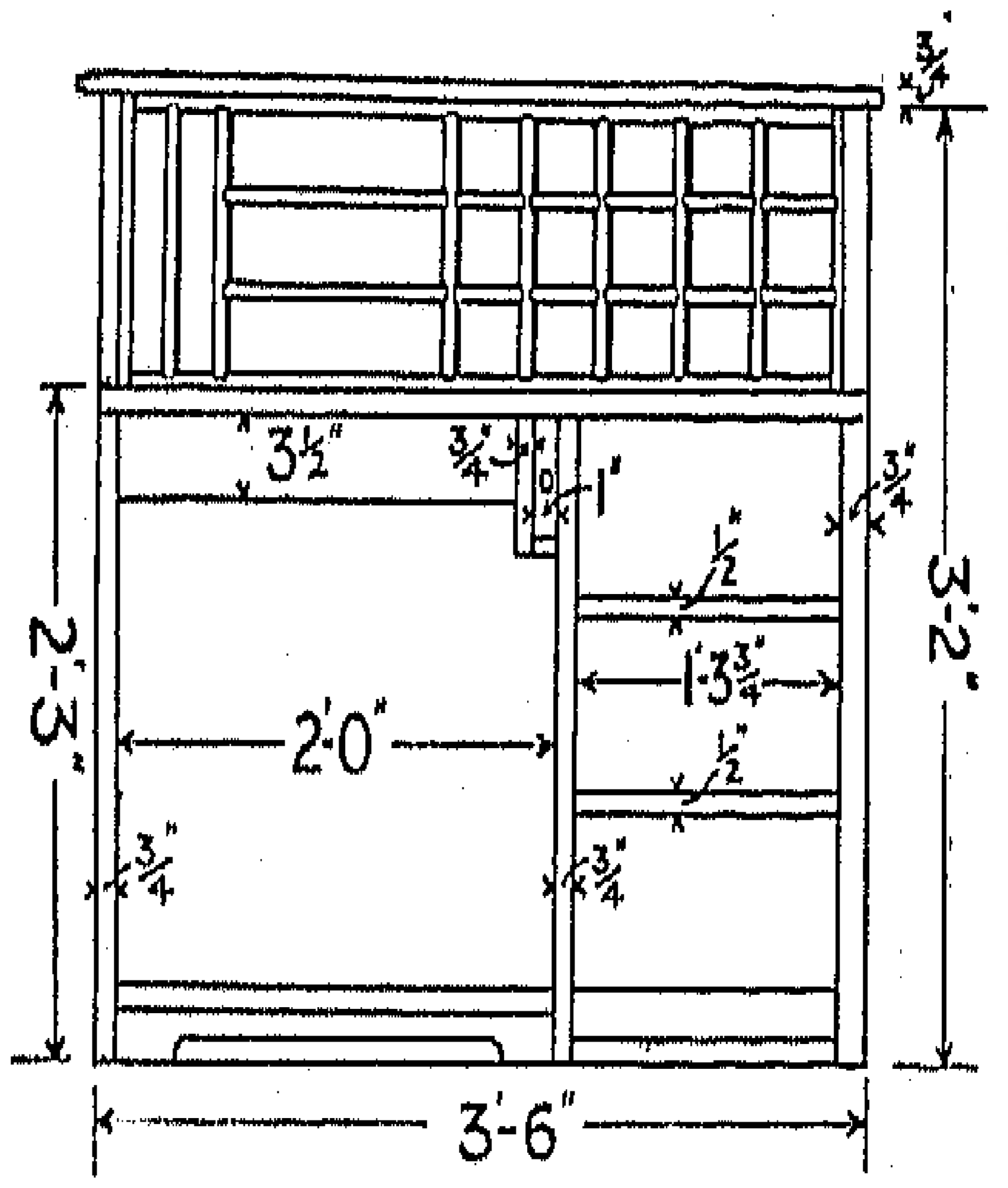


FIG. 5

FIG. 2



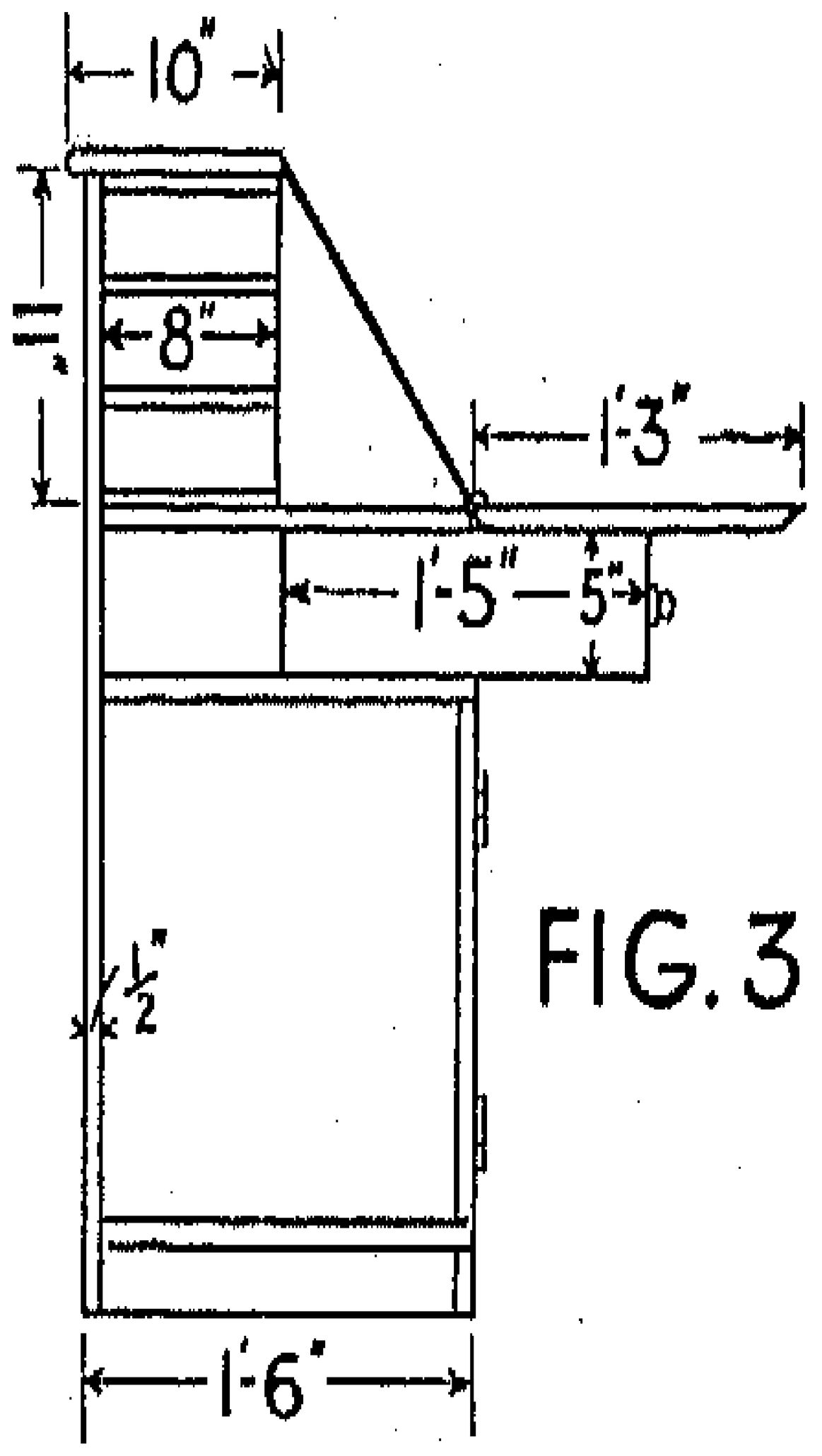


FIG. 3

BUREAU WRITING DESK

WORKING DRAWING Nº 7

and the flap and positioned approximately as shown in the perspective, Fig. 1.

The hinges should be of good quality cast brass (not stamped), and a suitable size is 1½ in. wide and at least 3 in. long when open. They are known as flap-hinges and should be fixed with brass screws, driven in tightly so that the heads lie flush with the surface.

The interior fittings consist of pigeon-holes and book racks. The form shown in the perspective view allows seven spaces for account books held vertically, two spaces for quarto note-paper, and a space for an inkwell, paste-pot, etc. An alternative arrangement is shown in Figs. 2 and 4, which has two quarto note-paper spaces, two book spaces and the rest square pigeon-holes.

Both fitments are built as a self-contained unit and slide into position at the back of the desk. If made to the dimensions shown in Fig. 4, they will fit accurately and are kept in place by means of screws or vertical fillets pinned to the inside faces of the side-members.

The frame for the unit should be of ¼-in. whitewood, with the vertical divisions made of the same material. The vertical pieces should be housed in grooves formed in the top and bottom boards, while the horizontal pieces can be of thinner material and supported by grooves cut in the vertical ones.

The best way to construct the unit is first to mark carefully and cut the various parts to size. Next mark the positions of the grooves on the top and bottom boards and cut the recesses with the aid of a tenon-saw, removing the waste with a sharp chisel.

In marking the uprights, sufficient allowance must be made at the ends for their entry into the grooves. The vertical pieces are then cut and grooved to take the ends of the horizontal pieces.

Assemble the frame, slide the partitions into the grooves and securely fasten them in position by driving oval brads through the top and bottom boards. Brush some glue into the horizontal grooves and slide the shelves into position as before, not forgetting to wipe off any surplus glue with a damp cloth. After sufficient time has elapsed to allow it to harden, trim the edges with a plane.

To improve the general appearance of the desk a half-round moulding ¼ in. wide could be fixed on the outside of the flap and the cupboard door to represent panels. The ends of the pieces forming the corners of the panels should be neatly mitred, and the parts fastened down with tube glue and ordinary pins, minus the heads. The moulding should be fixed at a distance of about 2 in. from the outer edges of both flap and door.

A DOG-KENNEL

A USEFUL type of dog-kennel which combines an inner and an outer compartment, the former cosy and draught-proof, and the latter having plenty of air by reason of the wired front, is shown in the perspective view in Fig. 1. Both compartments are readily accessible by full-opening doors hinged at the top and buttoned at the bottom, and an end door is provided for cases where the dog must be kept inside. Good height—not always provided—is another important feature of the design.

The constructional details of the kennel are shown in Working Drawing

No. 8, to which the figure numbers mentioned below refer.

The framing is shown in Figs. 1 and 2, and consists of six posts 1 in. by 1½ in. and 16½ in. long, square at the bottom (where they form short legs to keep the kennel off the ground) and cut to an angle of 60° at the top to coincide with the slope of the roof. They are joined at the top by boards cut to an angle, the boards being 1 ft. 4 in. long, 5 in. high to the apex and ½ in. thick. They are cut into the tops of the posts, as shown in Fig. 1.

Cross bearers, 1 in. wide and 1½ in. deep, are nailed across the bottoms of the posts for supporting the floor, and at the middle division a 2-in. cross-piece is nailed close to the floor against the backs of the posts. A vertical board 2½ in. wide is nailed in front of it to reduce the size of the rear compartment to 10½ in. This board may be wider if desired to make a narrower opening to suit a smaller dog. The 2-in. cross-member at the floor is to keep straw and bedding in the inner compartment.

The floor consists of two boards ¾ in. thick, which are cut in at the sides to clear the posts. The boards should have a matched, tongued and grooved joint, as shown in the end view, Fig. 2, to keep out the draught. They are nailed to the three bottom bearers which join the posts.

The back and the closed end are covered with ⅝-in. (½-in. finished) matched boarding laid horizontally. Two rails, each 2 in. wide, are fixed along the front at the top and bottom. The top one is chamfered to correspond with the angle of the roof, while the bottom one has plain square edges. The two front doors are hung between these two members from hinges screwed to the top rail.

In making up the framing, the three transverse frames, which are identical, should be put in hand first. The timber should be of good quality deal and all parts should be planed for the sake of sanitation. Rough wood harbours dirt and, maybe, insects, and is uncomfortable for the occupant.

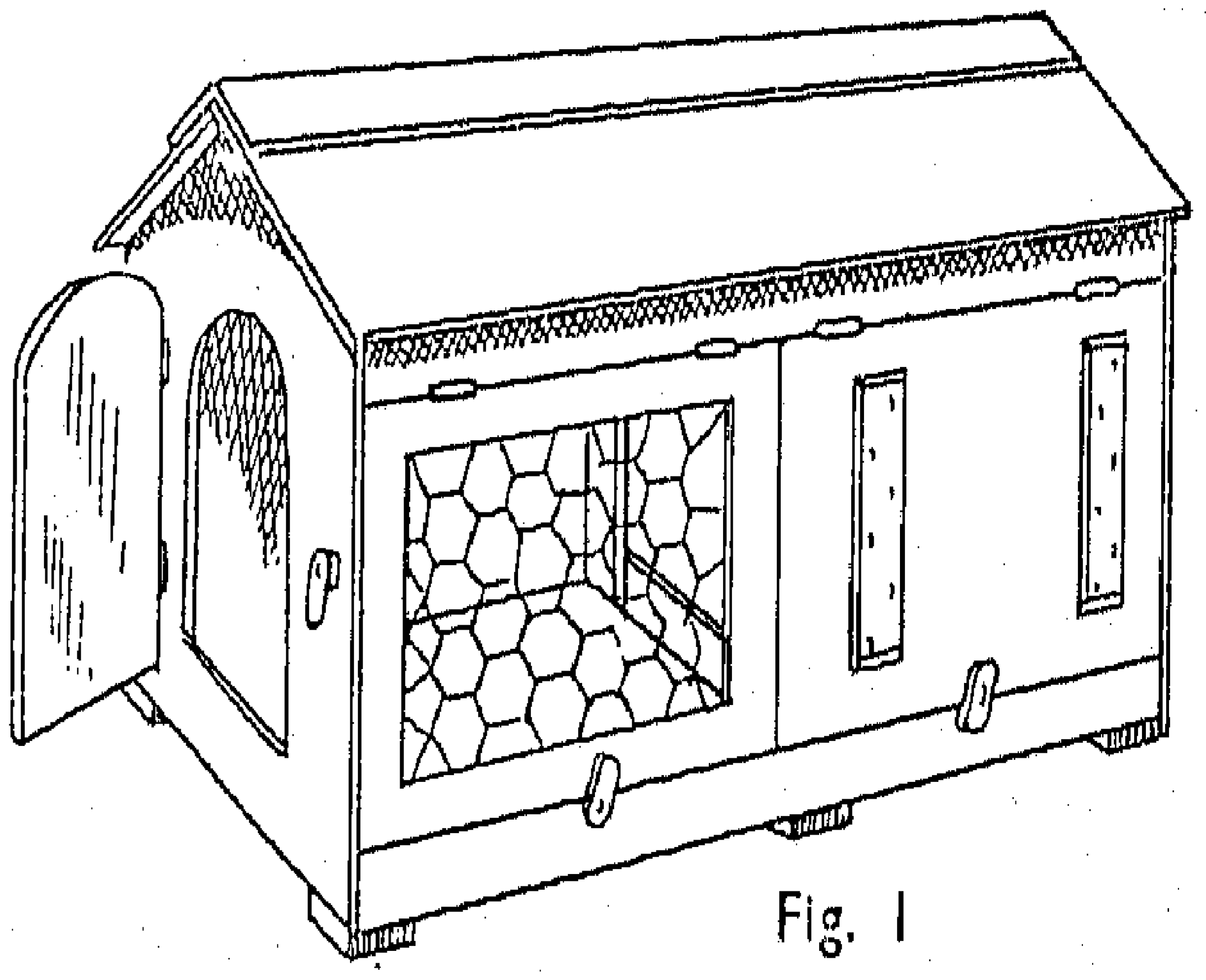


Fig. 1

The parts are simply nailed together with the roof supports and the floor bearers in place and form the three transverse frames.

At this point the constructor can decide whether to make the kennel longer to allow for more space in the outer compartment. If this is desired, the longitudinal dimensions given in the drawing may be departed from by the addition of as many inches as are required for the extra accommodation.

Having completed the transverse frames the next item to claim attention is to cut recesses in the floor-boards to clear the posts and then nail the boards down to the bearers, after which the roof may be nailed on. Fig. 2 shows how the two upper edges of the roof overlap each other at the top. The width of the roof from eaves to ridge is 11 in. and as it is constructed of ½-in.-thick material one member will be about (not exactly) ½ in. wider than the other, due to the overlap, as shown in the end section at Fig. 2.

The roof-pieces project beyond the ends of the frames by 2 in., but may be more if desired.

The ridge is formed of two pieces of ½-in. or ⅜-in. strips, 2 in. wide, with the joint opposite to that of the roof. It makes a neat finish and effectively seals any chance gap between the joints in the top of the roof.

The roof-boards are best in one piece but two pieces of 5½-in.-wide tongued and grooved boards may be used instead. To protect the wood and to ensure a watertight roof the boards should be covered with a good quality roofing material, or covered with one piece of thin zinc, neatly nailed on with galvanised nails, and the ridge-pieces could be put on over the material, in which case they would be for finish only.

The Two Side Doors.—Details are shown in Figs. 3 and 4. The long door of the fresh-air compartment is a frame of 1½-in.-wide by ¾-in.-thick planed batten. The corners are halved one upon the other and nailed and clinched. The outside measurement is 2 ft. long and 11 in. wide. The drawing shows galvanised-wire netting as the confining medium, but vertical metal rods, or even close-joint electrical conduit of ⅜ in. diameter, can be used if desired. These should be placed vertically and spaced 1½ in. apart.

If wire netting is employed the back of the door framework should be recessed and the netting fixed in the rebate from the back by means of galvanised staples, which should not be long enough to project through the front. A thin beading may be fixed at the back to protect the dog from any loose ends of wire.

The Door is hung on a couple of iron butt hinges. Select a cast-iron hinge, not a stamped-iron type, as the cast-iron ones last longer. One leaf of the hinge is sunk in the door frame and the other in the underside of the long top rail. A small wood stop nailed inside at each bottom corner prevents the door closing inwards and keeps it flush with the bottom rail.

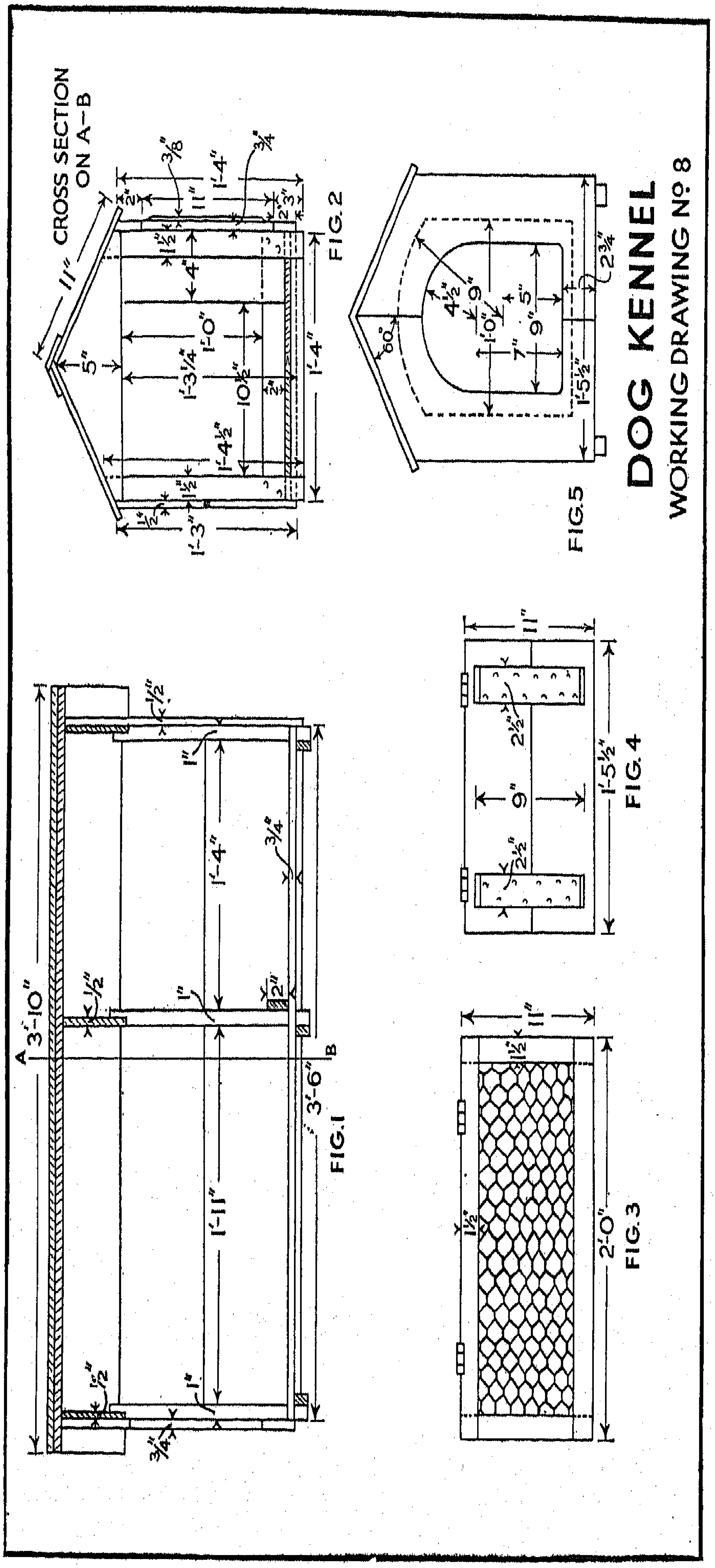
The solid door for the sleeping compartment is made of two pieces of tongued and grooved board 6 in. wide by ¾ in. thick, sawn and planed to a finished width of 11 in., and two battens, 2½ in. by ⅜ in., with chamfered ends nailed on, as shown in Fig. 4. It is hung in the same way as the netted door, and both are fastened with hardwood turnbuttons.

The Rear End of the structure is of ⅝-in. tongued and grooved matched boards, nailed to the roof support and the end framing; and the front is the same size and shape but should be of stouter material. The front can be made in two pieces, as shown in Fig. 5, and the door opening cut to the dimensions and shape indicated in the drawing.

The door for this is 1 ft. wide and made to the dimensions indicated by the dotted outline in Fig. 5. It can be hung on butt hinges—one leaf of each hinge fastened to the front of the kennel and the other cut into the back edge of the door.

A hardwood turnbutton is fastened to the front to keep the door shut.

The whole of the underside of the kennel should be treated with hot tar or creosote, liberally applied and well brushed into the joints. The exterior should have a good coat of lead priming paint, followed by two coats of any colour to choice, such as dark grey or green. It is not necessary to paint the inside but if desired it can be painted any suitable colour. The kennel may be kept cool in the summer by painting the outside of the roof a pure white.



A CYCLE SHED

A SERVICEABLE type of cycle shed with double doors at the end is shown in the accompanying illustration (Fig. 1), the details of which are given in Working Drawing No. 9.

The size of the structure is approximately 8 ft. long by 6 ft. wide, which allows sufficient space for the easy accommodation of four or five cycles.

For its construction the following materials will be required: A trifle over half a square of tongued and grooved floorboards, 7 in. wide, for the floor. If the shed is to be clad with tongued and grooved matching, which is much to be preferred to ordinary weatherboards, 2¾ squares of this material will be necessary for covering the sides, end and roof, while the quantity stated will include sufficient boards for the doors. For the framework, etc., four 8 ft. lengths of 3 in. by 2 in. scantling will serve as bearers for the floor. The floorboards are fixed to four joists, each 6 ft. in length, of 2-in.-square section stuff. Two 5 ft. 6 in. lengths of 3 in. by 2 in. will also be required for the door-posts.

For the front and back sections, four 7 ft. 8 in. lengths of 2 in. by 2 in. scantling will suffice for the top and bottom horizontal members or plates, and eight vertical studs or uprights, each 5 ft. 8 in. long, will also be necessary. Several pieces of 2 in. by 2 in., 2 ft. 4 in. long, will be needed for the intermediate horizontal pieces and the top of the window aperture.

The End Frame section is composed of two 6 ft. lengths of 2 in. by 2 in. stuff which form the plates, and four studs each 5 ft. 6 in. in length, while three pieces a trifle over 1 ft. 9¼ in. will be required for the horizontal pieces, as in the front and back sections. The two sloping members or roof-supports are 3 ft. 9 in. long, fixed to a vertical centre-piece 18 in. long, to give the necessary slope to the roof.

The Frame for the Door-end merely consists of a top and a bottom plate, each 6 ft. long, of 2 in. by 2 in. stuff, and two pieces of 3 in. by 2 in. scantling for supporting the doors—as previously mentioned. The top plate is surmounted by an 18 in. length of 2 in. by 2 in. scantling and two sloping roof-pieces of the same lengths as those at the other end. Four purlins, or longitudinal members, each 8 ft. 8 in. long, of 2 in. square material, will be required for the roof.

A supply of nails will also be required—about 2 lb. of 2-in. floor-brads, 2 lb. of 4-in. wire nails for fastening the framework together and 3 lb. of 1½-in. cut nails for fixing the matching. Eight 4-in. No. 10 wood-screws will be needed for securing the sections down to the floor, while a pair of 2 in. by ⅞ in. butt hinges and two pairs of 10-in. cross garnets are necessary for hanging the window and doors, respectively. A couple of 4-in. shooting bolts and a lock and key or a good quality padlock and staples will give the necessary security.

A roll of waterproof roofing material will be sufficient to keep the roof absolutely watertight, and ½ lb. of ½ in. galvanised clout nails will be ample for fixing it.

A piece of 21-oz. glass, cut to suit the sash, and ½ gallon of creosote complete the list, except for odd pieces of timber, small screws, etc.

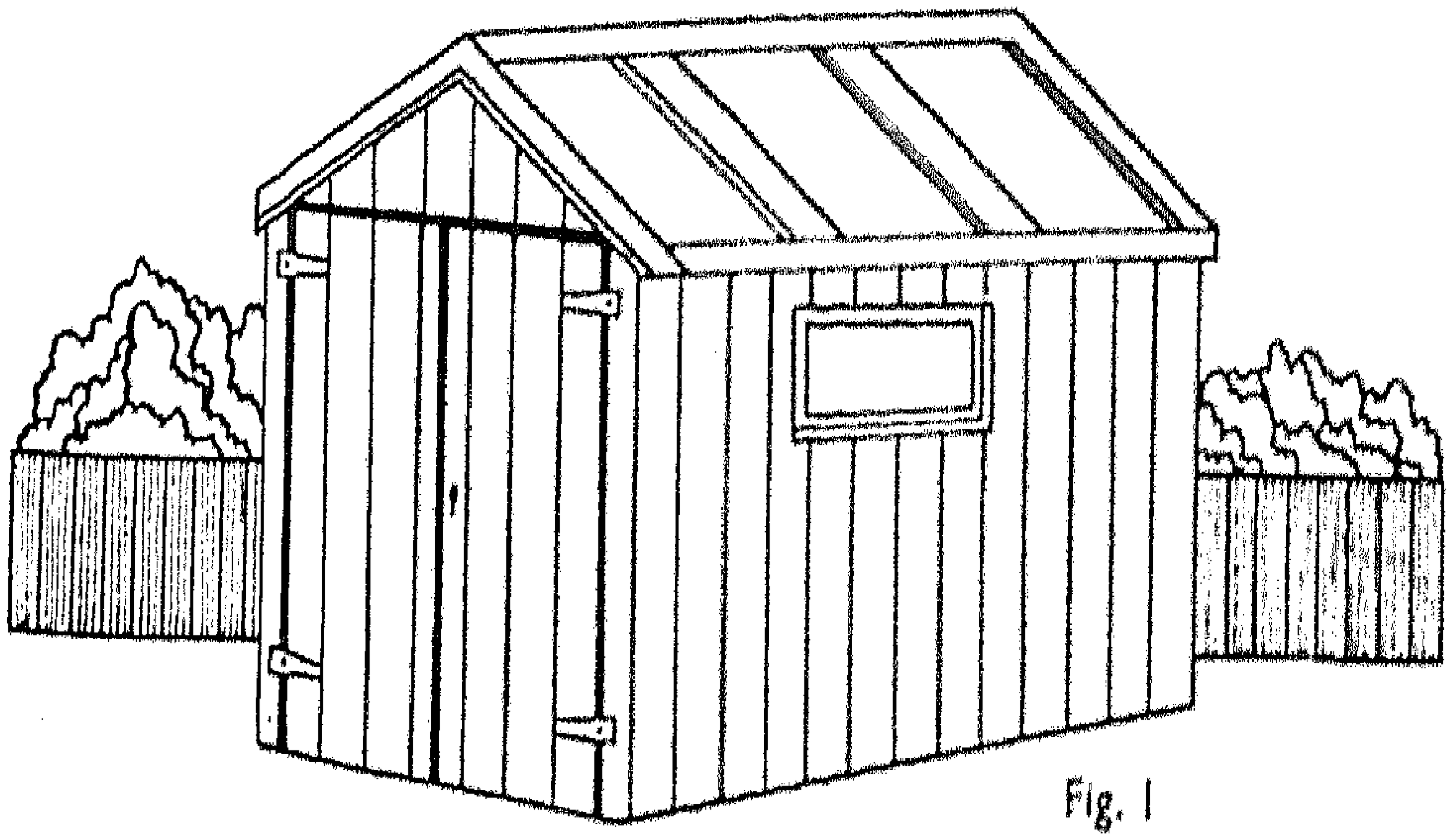


Fig. 1

As it is undesirable to allow timber to come in direct contact with the ground, a few bricks should be laid flat at each corner and also at equidistant spaces under the floor-joist bearers. It is important that the bricks be laid perfectly level and that the wide faces of the bricks lie uppermost. If the bricks are not true with each other, pack some earth under the offending member or members, or remove some of the soil as the case may be.

Waterproofing.—When the foundation is completed, the first thing to do is to cut off the floor-joist bearers to length and give them a good coat of creosote mixed with tar. This mixture is an excellent wood-preservative and its use will greatly increase the life of the timber by preventing rot.

Cut as many pieces of roofing material as there are foundation bricks, place them on the tops of the latter and then put the bearers in position, narrow faces up, of course. The covering pieces will prevent any wet absorbed by the bricks rising to the wood. Mark the positions of the joists on the outside bearers and fix the joists down to them by using the 4-in. wire nails driven in from the tops. Creosote the joists before fixing. Details of the bearers and joists are shown in the drawing.

Cut the floorboards to length and creosote the undersides and joints. To lay the floor, rip off the tongue of the first board to be laid and smooth the edge with a plane. Place the prepared edge of the board flush with the ends of the joists and nail it down. Now take the second board and push the tongue into the groove of the first. If you find that it does not fit easily, on no account hammer the bare edge of the board, but get an odd piece of flooring about 8 in. long and cut off the grooved portion. Insert the tongue of this piece into the groove of the board to be laid and hammer on the small piece. Hammering directly on the edges of tongued and grooved boards ruins them and very often leaves them in such a deplorable condition that it is almost impossible to fit them together.

When you have fixed about half a dozen boards, test the back edge of the last board for parallelism by measuring the distance at each end that this edge is from the front edge of the first board. If the measurements are equal it may be taken that the boards are parallel. If such is not the case, a little "give and take" at the joints in subsequent boards will rectify the matter.

When you come to fit the last board you may find it too wide to come flush with the edges of the joists, in which case you will have to rip the board to the correct width.

Follow with the framework, starting with the front and back sections. Note that the length of these is 7 ft. 8 in., and not 8 ft., as the odd 2 in. at each end is made up to 8 ft. by the thickness of the end posts of the end sections. Carefully mark the positions of the studs on the top and bottom plates and then cut and fix the studs. These are 5 ft. 8 ins. long and simply fastened to the plates by means of 4-in. nails driven through the top and bottom plates. The "nogging," or short horizontal pieces which fit between the studs, are not fixed in line, but "staggered" as shown. This method allows the fixing nails to be driven in horizontally and not skew-nailed, as would be necessary if the pieces were in line.

Do not make the mistake of making both side-sections exactly alike. One section has two horizontal pieces to form the window-frame.

The End Posts of the End Sections are 2 in. shorter than those of the front and back sections, to enable the top faces of the sloping roof-supports to register with the front edges of the front and back corner-posts.

Having completed the frames, test them for squareness and, if found correct, they can be clad with the matching. In doing this it is a good plan to start with the front and back members, and for convenience it will be found better to fix the boards to the framework with the frame resting flat on the floor instead of fixing the frames in their vertical positions and then nailing the boards on.

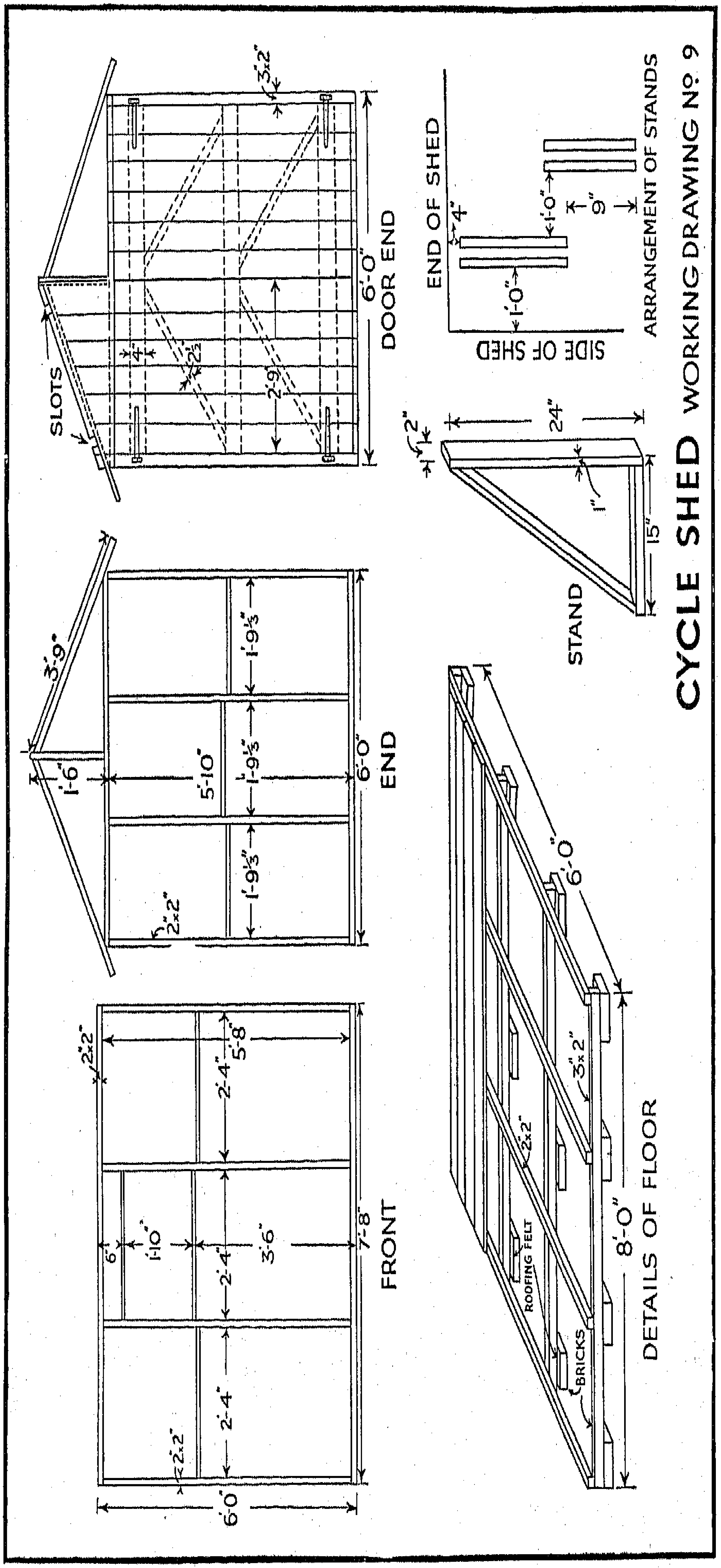
The boards should be cut to a length of 6 ft. 3 in., that is, 3 in. longer than the height of the frame, the top edges of the matching being kept flush with the tops of the upper plates. This allows the bottoms of the boards to overlap the lower edge of the lower plates by 3 in., and thus prevents rain water from percolating between the bottom plate and the floor. The 3-in. bottom overlap should also be provided for when cutting the boards for the end section, as well as a 2-in. overlap at the top to allow the purlins of the horizontal roof-members to rest on the sloping supports. The same amount of top projection must also be provided at the door-end for the same purpose.

The Roof is of the simplest character, and is not shown in the drawing. It is made in two sections, each of which is composed of matchboards nailed across two 8 ft. 6 in. lengths of 2 in. by 2 in. scantling.

In making the roof sections, the boards should be cut to project 6 in. beyond the sides and 4 in. at the ends. The edges of the boards at the roof ridge should project 4 in. beyond the long outside edges of the top purlins, while the other ends of the boards should project 12 in. from the lower ones.

Having completed the roof, give it a coat of creosote solution. When dry, fasten down the roofing material with galvanised clout nails and further secure it with four $1\frac{1}{2}$ in. by $\frac{1}{2}$ in. planed and chamfered battens, one at each end and two equally spaced between them. The top or ridge ends of the battens should be fixed 4 in. from the top long edges of the roof boards to allow sufficient space for the ridge cover, and they should be fixed with screws.

The next procedure consists in assembling the sections. Get a helper to hold a side section while you screw the end section to it. Take care to see that the inner faces of the projecting matchboards at the bottom butt up close to the edges of the floor. Now fix the other side section and then the front and fasten the bottom plates down to the



floor by means of 4-in. No. 8 countersunk-headed wood screws.

Place the roof sections in position and cover the small gap where the boards join at the apex with a 7-in.-wide strip of roofing material so that the long edges reach to the tops of the roof battens.

Then make the ridge capping with two 8 ft. 6 in. lengths of ½-in. planed batten. The width of the battens should be 4 in. and 4½ in. respectively. They are nailed together to form an inverted V, after one long edge has been planed to suit the angle of the roof. Give the capping a coat of creosote and screw it down to the roof, using 1-in. No. 8 screws for the purpose.

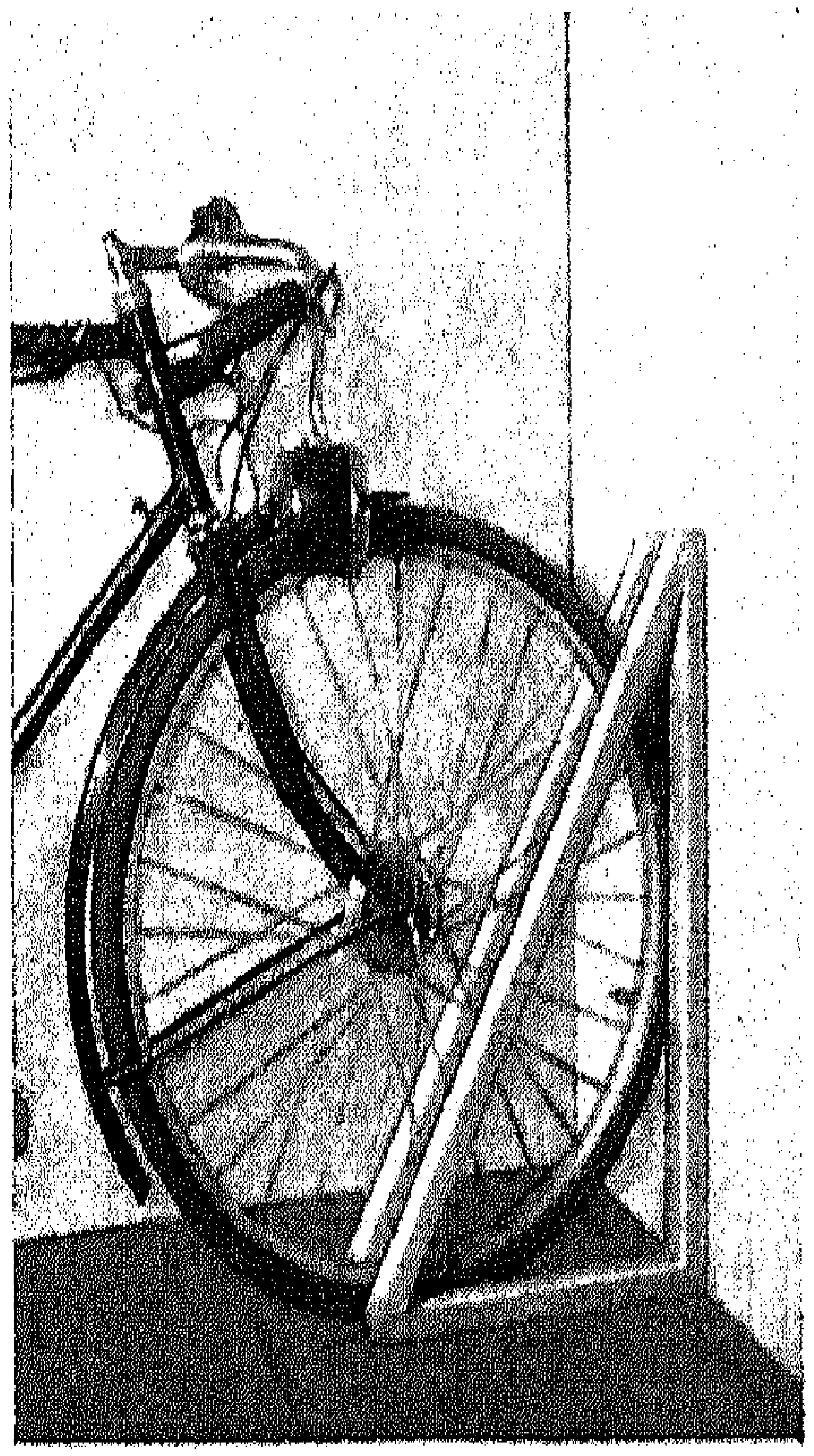


Fig. 2

The doors are of the ordinary ledged and braced type, and to ensure a good strong job they should be fitted with three ledges about 4 in. wide, of 1-in.-wide material, while the braces should be at least 2½ in. wide. In fitting the braces, avoid the error of sloping them all one way—the braces of each door should slope upwards from the hinged edge to prevent the doors sagging. The ledges and braces are shown in the door end view.

The cross garnet hinges are fixed by screws driven into the door-posts and through the matching into the top and bottom ledges, keeping the centre pins in line with the joints formed between the edges of the door-posts and doors.

The Window has a sill projecting about 2 in. beyond the outside face of the matching. It is also necessary to line the sides and top of the window aperture with suitable lengths of 2½ in. by ½ in. planed batten. For a fixed window, all that is then necessary is to nail some 1-in.-by-½-in. strip round the frame to form a support or rebate for the glass. The lining and the rebate should receive a coat of priming paint before the glass is placed in position and fixed with putty. If an opening sash is desired, the stiles and rails should be constructed of 1¼-in.-by-1¼-in. stuff, using either morticed and tenoned joints or halved joints at the corners. False rebates can be made with narrow strips of wood bradded to the inside faces of the frame in the same manner as that mentioned for supporting the glass in the fixed window.

When the door bolts and other fittings have been fixed, the whole of the exterior should be treated with a liberal supply of creosote, or, if preferred, two or three coats of good quality lead-paint.

The final operation is to construct and fix suitable stands in the interior for the accommodation of the cycles. These should be fitted at the end. Such stands can be easily and quickly constructed with ordinary 2 in. by 1 in. batten, cut and fixed together to form triangular frames as shown in detail in the drawing. Two frames will be

required per cycle, because the front wheel is inserted between them as shown in Fig. 2. The frame parts should be screwed together. Each pair of frames is then fixed down to the floor by means of screws driven through the bases. The two members forming a frame should be spaced 2 in. apart, while the first pair of frames should be fixed at a distance of about 4 in. from the end wall and 1 ft. from a side wall. The next pair should be fixed 1 ft. away and 9 in. in advance of the first fixture, to economise space, as shown in the Working Drawing.

The little extra time and material involved in making the stands will be well compensated for by their convenience, and also by preventing damage to the enamelled surfaces of the cycles.

SPAN ROOF GREENHOUSE

The greenhouse shown in detail in the Working Drawings Nos. 10 and 11, presented separately with this book, is constructed of timber frames standing on a foundation of two courses of brickwork laid in "stretching bond." Damp earth inside and out is well below the level of any woodwork. To avoid having a step inside the doorway, the surface of the site is 3 in. below the top of the upper course of bricks. The floor may be of earth, with a centre pathway of bricks, flat stones, or concrete.

The Foundation.—The soft top soil over an area a little larger than the greenhouse should be cleared away to a depth of about a foot or more, the bottom well rammed, and the excavation filled with stones and broken bricks, each shallow layer being well rammed or rolled down firm and level. Fill up all the odd spaces until the whole site is well covered and firm. If this part of the work is put in hand early, while the timber-work is being made, it will give it time to settle, and a little more material may be added and rolled in from time to time, especially after rain.

Lines for laying the brickwork may be set out and indicated by means of thick string stretched between pegs set firm just beyond where the corners come, so that the strings at right-angles indicate the exact corners and the outer faces of the walls. The floor space *inside* the walls is 7 ft. wide by 10 ft. long, and the walls are one brick (4½ in.) thick. At the corners the courses interlock, and are laid in cement as described elsewhere. Wood plugs or blocks are inserted at intervals along the top course. To these the lower sill is nailed. Attention can now be given to the timber-work.

Much of the framework may be completed in sections to give two ends, one with a door-opening and the other with a central post 2 in. by 2 in. set back ⅞ in. on the sill with a barefaced tenon end as for the other intermediate posts.

The Door End consists of two corner-posts 3 in. by 3 in. stub-tenoned at the foot into the lower sill, and braced across the top by the 2½-in. by 1¾-in. head, let into the outer face of the post as detailed. This end of the post is cut to the slope of the roof, which is 30°.

Timber 3 in. by 2 in. is used for the lower sill, or plate, and laid with the 3 in. face on the top of the brickwork and 1½ in. back from the front outside face of the wall on all four sides. The corners are halved and the mortice-holes cut for the stub tenons after the lower sill frame has been fitted together. The complete sill, ready to place in position, measures 7 ft. 6½ in. wide by 10 ft. 6½ in. long overall.

Door posts of 3 in. by 2 in. timber are fixed 2 ft. apart and central as shown, with a 2-in. face outside. The foot ends are cut as detailed, the outer 2-in. wide face of the lower sill being cut 2 in. wide by ⅞ in. deep to allow the door post to go back flush with the sill. The top ends of the door posts are fitted behind the head as shown, the face of each post being cut back 1¼ in. by 2½ in. to suit.

The Upper Sill, prepared from 4-in. by 2½-in. material, is housed into the side of the corner and door posts, as detailed. The outer face is left solid to mask the joint. On the inner faces of both door and corner posts mortices are cut for the ends of each length of 1-in. square rail fitted under the upper sill to provide a background ⅞ in. back to nail the vertical boarding to. A similar piece of 1-in. rail is nailed along on top of the lower sill for the same purpose, but is only fitted between the posts and not morticed in.

Battens 1 in. by ½ in. are nailed to both inner faces of the door posts for stops.

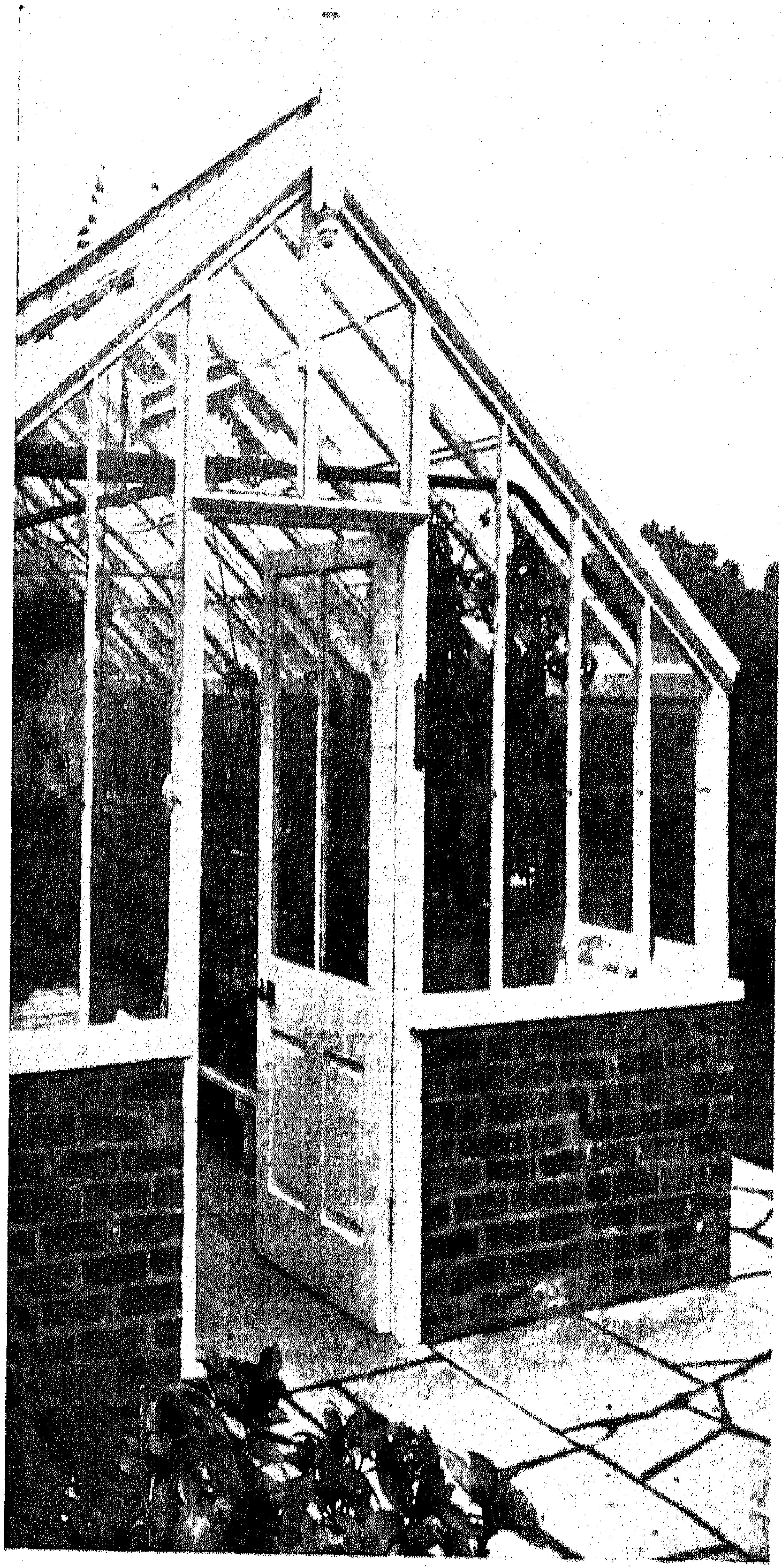
Two lengths of sash-bar are required to make the window on each side of the doorway. The bottom end of each piece is cut as detailed, to make a tenon ¼ in. thick by 1⅛ in. long to be let into the sill to a depth of ½ in. At the top ends the front web which makes the ⅜-in. division between the pieces of glass is cut away a full ⅝ in. for a distance of about 2 in. from the end, thus leaving a flat face 1⅛ in. wide to butt against the back face of the head-board. A fillet of ⅜ in. thick by 1 in. wide strip is nailed to the under edge of the head, along the sill between the sash-bars, and down the edges of the door and corner posts, so that their surfaces behind the glass are all flush, making a rebate for the glass. The glazed space between door and corner posts is divided into three sections by two sash-bars. This gives a glass size of 9 in. wide. As near as possible lengths of 18 in. are used; the middle piece overlaps the bottom piece, and the top one overlaps the middle pane, as indicated, so that the rain will not run inside. 21-oz. glass is used for all panes, and is secured by means of sprigs or brads driven partially into the wood, leaving part of the head bearing against the glass, and afterwards filling the angle or corner with putty. In the vertical sections above the bottom panes, sprigs driven into the wood will prevent them slipping down, or pieces of sheet zinc may be cut and bent to form hooks and nailed to the wood, for the same purpose. Where putty is to be used, the woodwork must be painted with red lead paint, otherwise the putty will not hold.

The door is 2 ft. wide by 6 ft. 6 in. high and may be obtained ready made, or home constructed, as desired. Builders often have odd used doors from which a selection can be made.

Each Side Frame consists of a 3-in. by 2-in. post at each end, with three intermediate posts of 2 in. by 2 in. in section, one placed central and the others on each side at 2 ft. 3½ in., as shown. The foot ends are cut to form barefaced tenons, in mortices cut ⅞ in. back from the edge of the lower sill to leave room for the vertical boarding. The top ends are cut on a 30° slope at the front and the 2½-in. by 1¼-in. timber may be carried across in the same manner as the head-board used on the outside of the ends, and fitted in the same way. A rebated rail prepared out of 1½-in. by 2½-in. timber and cut to 30°, as shown at E in the detail of this part, is tenoned at each end into the posts.

The sash-bars are tenoned into the upper sill as before, and the top ends are cut with a tenon at right-angles, ⅞ in. by ⅜ in. in the under face of the rebated rail E, as in the detail.

The two end posts are fitted to the sill in the same manner as the door posts



IN THIS EXAMPLE THE BRICKWORK IS 3 ft. HIGH in the end frame, by cutting the notch in the outer face of the sill and letting the post go back flush.

The cutting of the upper sill will have to be a little different at the intermediate posts, as shown in the detail. At the ends the housing is on the same lines as before, but as the post is 2 in. deep, the solid part of the sill on the front face will be 2 in. thick, and will overlap round the front face of the post by 1 in. as before. The intermediate posts will have the housing groove cut on the front face so that the sill is cut at the back.

Matched and V-jointed boarding, ⅞ in. thick, is fitted all round the walls between the two sills. The front face is flush with the end posts, which are the only ones that show; the others are covered by the boarding.

The Eaves Board, marked D, is ⅞ in. by 6 in. wide and extends the whole length of the house, and is fixed to the sloping tops of the posts. The ridge board A is fixed in the notched tops of the centre posts and a 3¾ in. by 1½ in. thick board is nailed to the ridge and carried over the eaves board, that end being reduced to ⅝ in. thick for this, so that the ⅞ in. board is underneath. Boarding, 3 in. wide by 1¼ in. thick, fixed on edge completes the gable end. This board also has its lower edge cut away to pass over the ridge board, although the latter could be made that 1¼ in. shorter at the end so that the gable board covered the edges of the timber behind it.

Two Ventilator Frames cover a framed opening in the roof, one as shown at two glass pane widths from the end, and the other at the same distance from the other end but on the opposite slope. The framing consists of 2 in. by 1¼ in. timber with the two horizontal members B and C fitted between, with mortice-and-tenon ends, or a stepped housing joint. If the ventilator is fixed farther along the roof, between the position of the intermediate posts, it would be three panes of glass wide, with a framed opening to suit. Hinges and a casement-stay fitting will be required for each.

A POULTRY-HOUSE AND RUN

The poultry-house and run shown in the sketch at Fig. 1 is designed to give ample room for the accommodation of twelve birds.

It will be seen from the illustration that the roosting-house is raised two feet above the ground level. This feature serves three useful purposes. Primarily, it provides additional space to the run; secondly, it does not harbour rats and other objectionable vermin as so many houses do that are built only a few inches off the ground; and lastly, the floor of the house above provides a shade from the sun during the summer months.

It is a well-known fact that good lighting has a beneficial influence upon fowls, and this has been provided for by the large aperture in the front, which is covered when not in use by a vertical sliding shutter.

Nest-boxes.—Another feature is the disposition of the nest-boxes in a detachable unit arranged to fit across the front of the structure. The position has not been chosen for the convenience of the egg-gatherer alone, but because it happens to be in the darkest part of the house, which, as is well known, is the best position for such boxes.

A door is provided at the side, but this position is optional. If there is not sufficient space to gain entrance from the side, the nest-boxes could be transferred to the side, and the door to the front; in which case it would be necessary to alter the general arrangement of the framework by shifting the window to either the right- or left-hand side of the front.

The small trap-door between the house and the run is operated from the outside by means of a cord passing through a couple of screw-eyes fixed in convenient places in the side of the structure. This simple device saves the bother of entering the run every time the trap-door has to be opened or closed. It is kept in the open position by placing the looped end of the cord over a rail.

Two removable perches are provided, fixed at a height of 1 ft. above the floor-level. The width of these should be about 3 in. and the tops should be rounded.

The Total Length of the house and covered run is 18 ft.; 6 ft. being the length of the house and 12 ft. that of the run.

This measurement is necessarily an arbitrary figure because the length of the run can either be reduced by a couple of feet or added to, according to the amount of space available. It should be borne in mind, however, that it is better to increase the size than decrease it.

The covered run calls for no particular comment, except that it may be an advantage to add a hood in front, for further protection in bad weather. The height should be a foot or so less than that of the roosting-house, and the slope of the roof made to correspond.

The framework of this part is constructed of 2 in. by 2 in. section deal, and is covered with planed and rebated weather-boards at the back end and part of the front, while the top is covered with ⅝-in., V-jointed tongued and grooved matching.

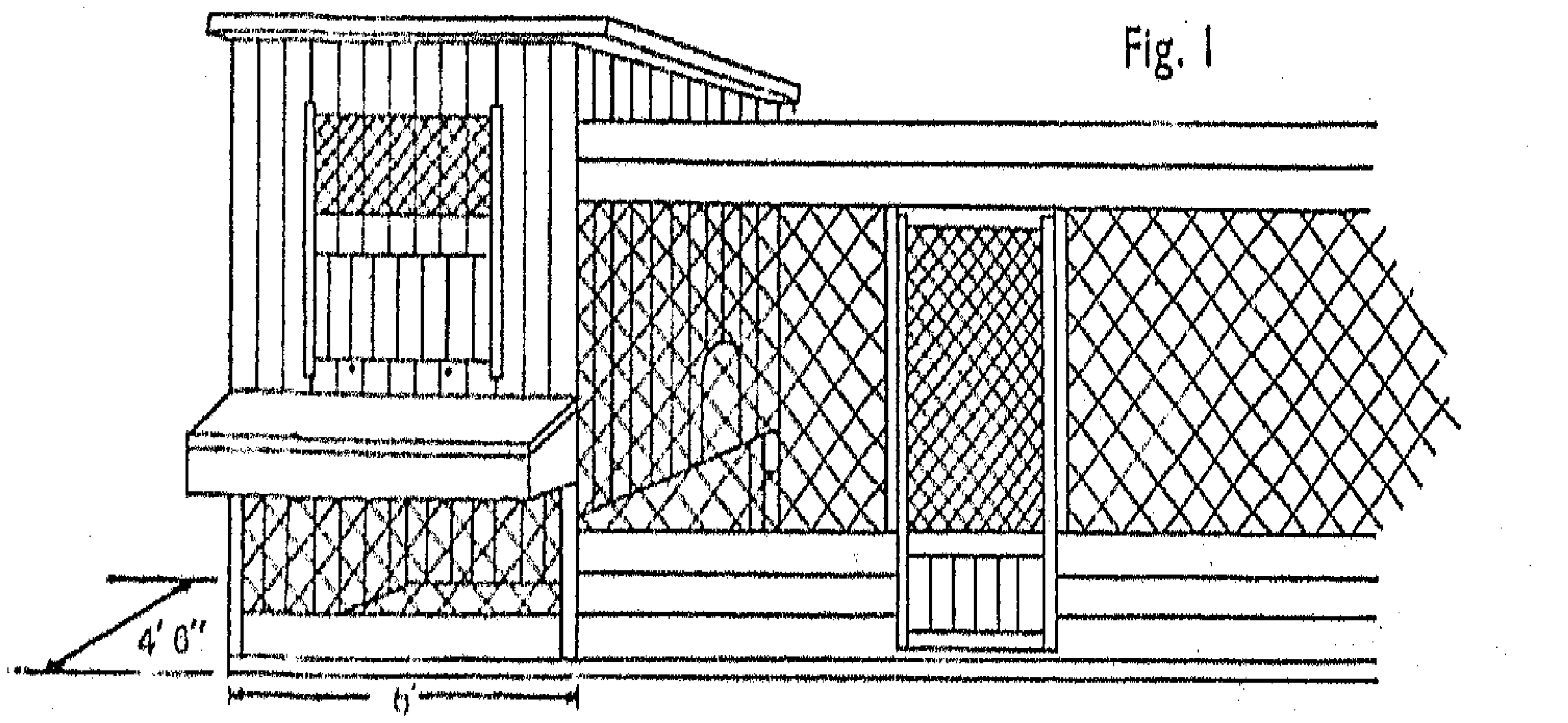


Fig. 1

The Roosting-house is made in sections, each of which is framed with 2 in. by 2 in. section deal. Tongued and grooved V-jointed matched boards, 6½ in. wide and ⅝ in. thick are used for covering purposes.

Tongued and grooved floorboards 1 in. thick, placed across the narrow width of the structure, are used for the floor, and are purposely left loose for cleaning purposes.

The whole of the structure is supported on two 18 ft. lengths of 3 in. by 2 in. deal. This method of support will be found much more effective than the usual way of placing the uprights on bricks, which soon sink into the ground and thus throw the structure out of truth. The legs of the house are held in position by means of small metal angle-brackets screwed to the legs and foundation plates, an arrangement which allows them to be easily removed without damage, should the necessity arise.

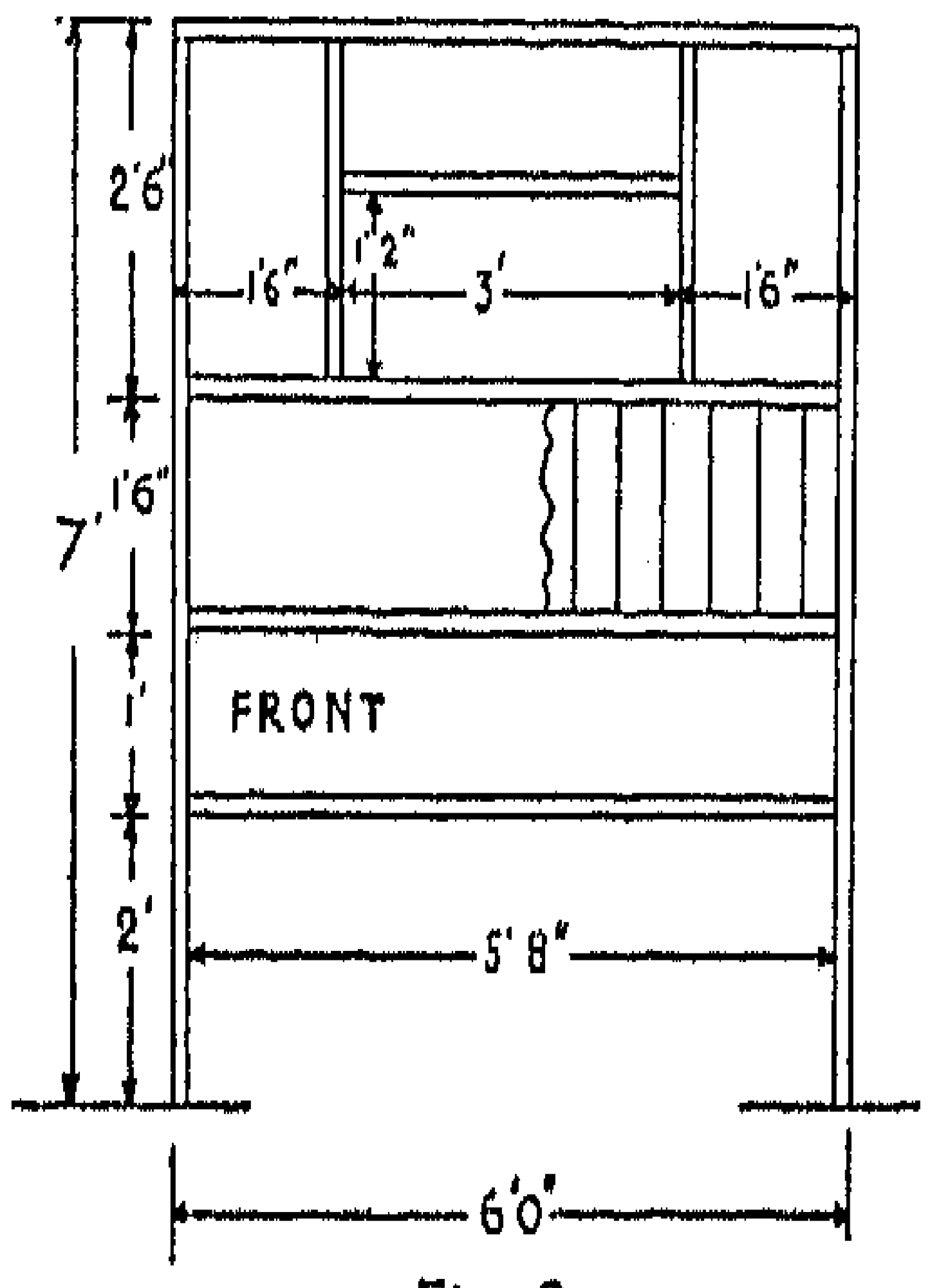


Fig. 2

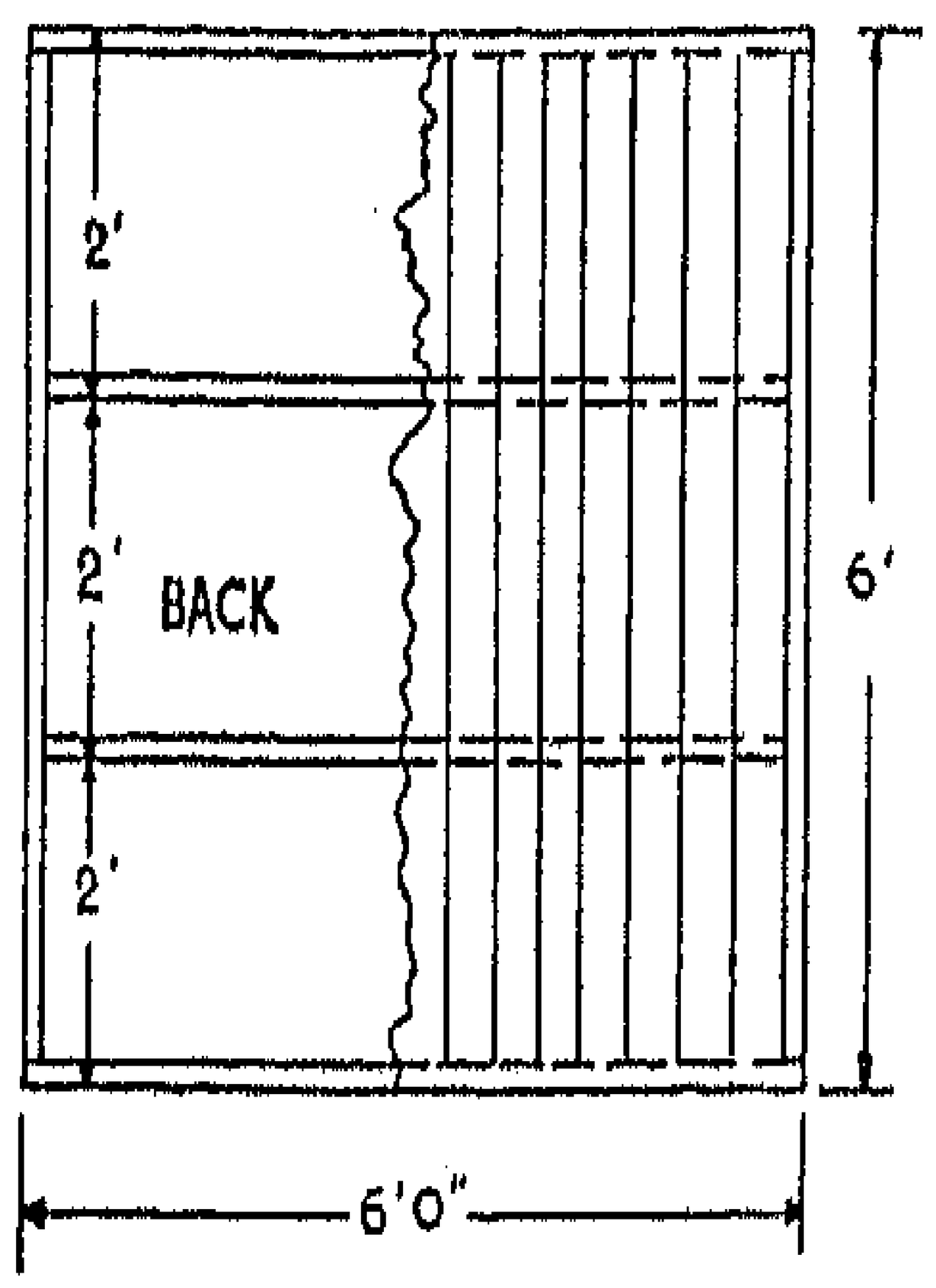


Fig. 3

The following is a list of the necessary materials for constructing the roosting-house and run:

Framing—250 ft. run 2 in. by 2 in. deal.

Foundation plates — two 18-ft. lengths, 3 in. by 2 in. deal.

Matchboard—2½ squares V-jointed, tongued and grooved boards—6½ in. wide and ½ in. thick.

Weather-board—1¼ squares planed and rebated, 6½ in. wide by ⅝ in. thick.

Batten—50 ft. run 3 in. by 1 in. and 32 ft. run 2 in. by 1½ in., both prepared deal.

Flooring—Twelve 4 ft. 6 in.-lengths, 6 in. by 1 in., tongued and grooved.

Miscellaneous—Eighteen 3-ft. plasterers' laths, a supply of 1¼-in. cut and 4-in. wire nails. 1-in. mesh, galvanised, wire netting—British make, not the cheap, foreign kind if durability is desired—and ½ in. galvanised staples for fixing it. Roofing felt and ½-in. clout nails (galvanised), for fastening it down. Half a gallon of creosote. Four 8-in. cross garnet hinges and four ⅜ in. by 5 in. round-headed bolts and nuts, etc.

Start by sawing up the scantlings for the framework for the house to the dimensions shown in the drawings (Figs. 2, 3 and 4). Mark each member as it is cut and keep the parts for each section in a separate pile to avoid confusion.

Next, assemble the parts. This is quite a straightforward job, as the members are simply butted together and fixed with 4-in. wire nails. To avoid splitting the wood, bore holes in the outside members to be joined by using a drill of slightly less diameter than that of the nails.

Having completed each sectional frame, fix the matchboards to the front section. Start at the right-hand end and fix the first board, allowing ½ in. overlapping after having removed the tongue. The overlap covers the ends of the boards on the side section and consequently makes a neat flush finish when erected. A similar overlap is, of course, necessary at the other end.

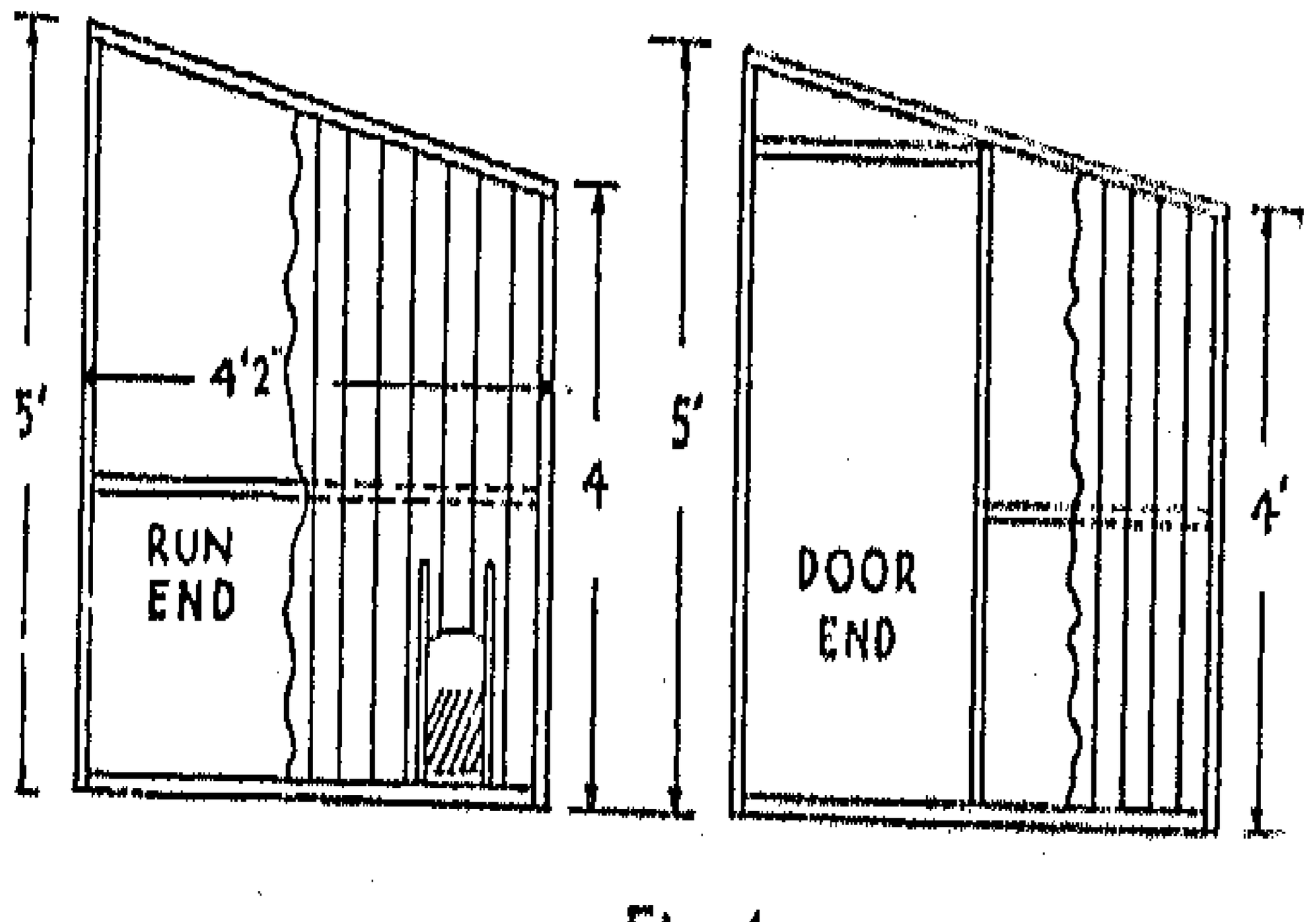


Fig 4.

When cutting the boards for the front section do not overlook the fact that the bottoms are fixed to the third horizontal rail and not the floor rail, as the space between these two members will be occupied by the nest-box.

When fitting the boards, it is a good plan to cover the whole area and then cut out the window aperture with the aid of a padsaw. If this is carefully done the waste can be utilised later. Fix a piece of 1-in. mesh wire netting over the aperture by fastening to the inside framing.

As creosote is much to be preferred to paint as a preservative medium for poultry-houses, owing to its excellent disinfecting qualities, each joint should receive a coat as the boarding proceeds.

Matchboard the back section in the same manner, not forgetting the ½-in. overlap at each end. The boards of this section extend from the top of the frame to the bottom.

The boarding of the sides calls for little comment except that care should be taken to see that they are covered on opposite sides and that the door-post must be perfectly square with the rest of the frame.

When all the sections are complete, give them a good coat of creosote on both sides and, whilst this is drying, proceed with making the roof.

The Roof fits on the top of the structure like the lid of a box, as will be seen clearly by referring to the illustration (Fig. 5), the dotted lines representing the tops of the walls of the house.

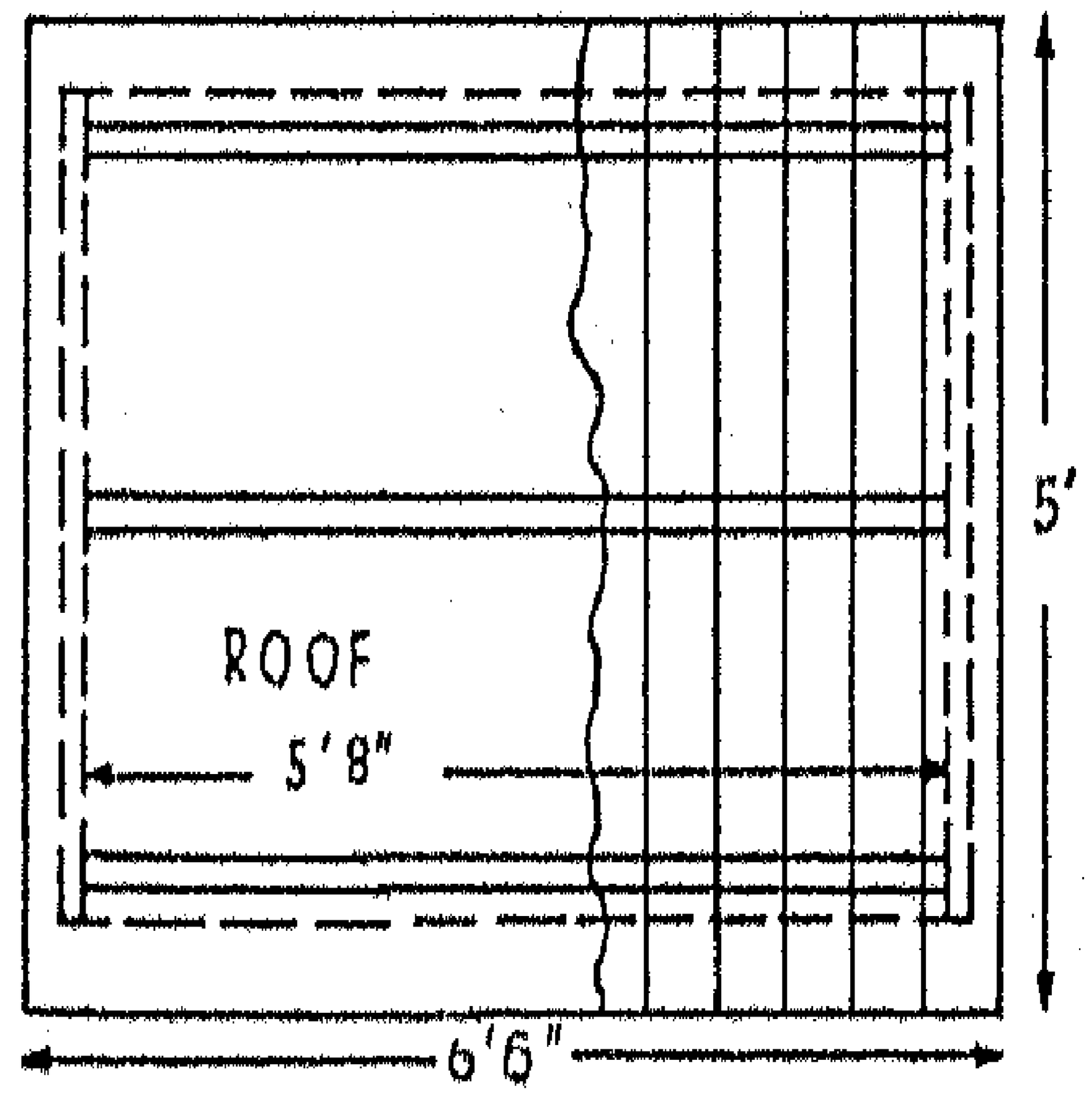


Fig. 5

It will be observed that each end board is only partly supported by the longitudinal rafters, but these boards are further supported by the top cross members of the sides when assembled.

After the roof boards have been fixed, remove the sharp edges all round with a plane, to prevent them cutting the roofing material.

Give the roof a good coat of creosote on both sides.

The next procedure is to construct and fit the sliding shutter to the front section; details of this are shown in Fig. 6. The overall size of the shutter is 3 ft. 4 in. long and 1 ft. 6 in. wide. It consists of matched boards held together by two vertical battens as shown. The shutter slides in rebates or grooves formed by nailing pieces of 2-in.-wide batten over pieces 1 in. wide, which are then fastened to the front by means of screws.

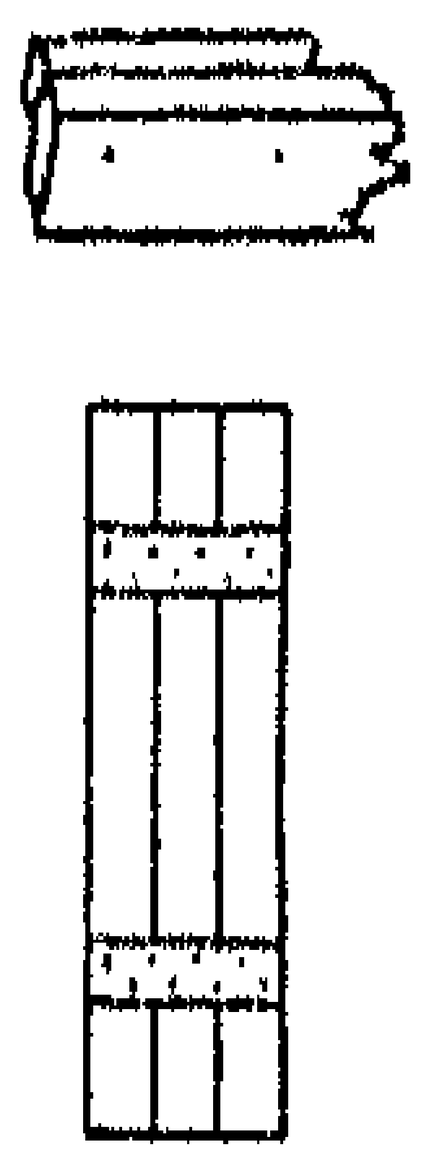


Fig. 6

The Door is of simple construction, consisting of matched boards fastened to three ledges or battens. The length of the ledges should be ½ in. shorter than the total width of the door, to allow it to close against the door-stop. The latter consists of narrow strips of wood, ⅜ in. thick, nailed to the inside faces of the door frame.

When the holes for the fixing bolts have been accurately marked and bored, the structure is ready for assembly. Before this can be put in hand, however, the site should be prepared. If the ground is soft where the foundation plates are to rest, it should be well rammed down and more soil added if necessary to bring it up to the correct level.

Give the plates a thorough coat of creosote and, when dry, place them in position, wide face down, and test to see that they are perfectly level by means of a spirit-level.

The long outer edges should be 4 ft. 8 in. apart. They can be kept at this distance for the time being by nailing two or three pieces of batten across.

It will now be a wise expedient to obtain the services of a helper to assist with assembling and bolting the sections together and fitting the roof. When the four sections have been bolted together, test for squareness and verticality by means of a square and a plumb-bob. If correct, fit the roof, which is secured by driving 4-in. screws through the sides of the structure into the ends of the rafters.

Fit a small iron bracket to the inside face of each front leg and screw this down to the front foundation plate; the back is secured to its plate by driving in two 4-in. screws through the bottom of the frame into the plate.

The Roofing Felt.—Two 7-ft. lengths of standard width (3 ft.) material will be required, which allows 3 in. all round for turning under the edges and 3 in. overlap at the horizontal joint in the centre of the roof. Start fixing at the front edge and work towards the back, using ½-in. galvanised clout nails, spaced about 3 in. apart, for fastening purposes.

Fold the overlapping portion neatly over and under the edges of the roof and fix it securely by nailing home laths on the underside. Finish off the roof by nailing down the three battens—one in the centre and one at each end.

The Floorboards.—Cut and fit, but do not nail them down, and fix the door to its post and the door-stopping round the inside face of the frame. Make sure that the door closes properly against the stop and that the outside of the door is quite flush with the rest of the surface.

Now make the nest-box according to the details shown in Fig. 7, and fasten it to the structure by driving screws through the projecting ends into the two inside faces of the front uprights. The lid should be covered with roofing felt, and sufficient material should be left at the back to enable it to be fastened to the front of the house and thus form a watertight joint. The cross garnet hinges can now be fixed in convenient positions.

Mark the position and cut the small aperture for the trap-door at the side with the aid of a padsaw, and then construct the door and the rebated side-pieces for keeping it in position. The side-pieces may be made in the same way as that suggested for the front shutter.

The Run.—Mark and cut the front and back uprights and mark the exact positions for these on the foundation plates. The back uprights are spaced equally apart, while the front ones can be either arranged to allow the door to adjoin the roosting-house or in any other position to suit the convenience and taste of the constructor.

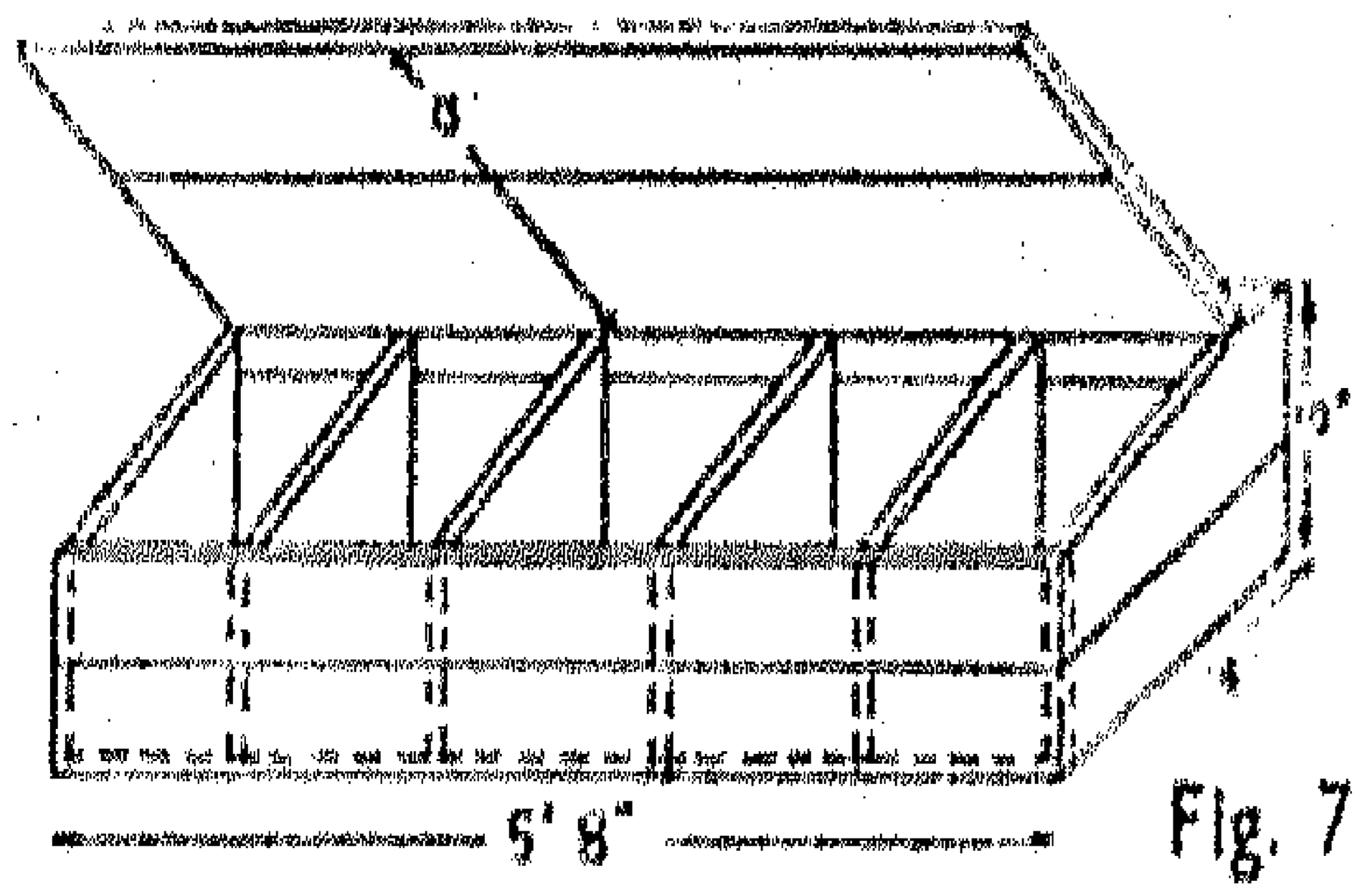


Fig. 7

Fix the uprights to the foundation plates by means of the iron brackets in the same manner as that mentioned for the front legs of the roosting-house. The front and back uprights adjoining the roosting-house should be fixed to it with screws.

Carefully mark the positions for the tops of the uprights on the long, horizontal top pieces and then fix these members to the uprights with 4-in. wire nails. Before driving the nails home make perfectly sure that each upright is absolutely vertical and square, as nothing offends the eye more than seeing an object which should be upright leaning over at an angle.

Having satisfied yourself on this point, the next thing to do is to fix the cross

pieces. These are placed squarely across the horizontals and fastened with nails, the ends being cut off flush with the front after fixing.

Proceed by fitting the rebated weather-boards to the back and side, starting at an inch above the bottom of the foundation plate and working upwards towards the roof. Test the long edges of the boards with a spirit-level from time to time during erection in order to check any deviation from the horizontal, and do not forget to creosote the joint as each board is fixed.

Saw the matched boards for the roof to length, namely, 12 ft. 4 in., and when securely fastened down give the whole structure a good coat of creosote. When dry, cut and fasten down the roofing material in the same manner as previously described.

The Door is the next item to make. There are several ways of doing this. The best method is to use morticed and tenoned joints, but if this does not appeal, halved joints may be used at the top and bottom, and the middle rail fixed either with nails or screws, the latter being preferable. Another method would be to butt and screw the members together and reinforce the joints by using metal angle-plates. Such plates are to be obtained quite cheaply at most hardware stores.

Having completed the frame of the door, the lower portion should be filled in with matched boards, held in place by first nailing "fillets" or narrow strips of wood about ¾-in. thick around the inside faces of the frame to form a rebate, and then driving nails through the boards into the fillets. The fillets should be fixed ½ in. back from the front edge of the frame to enable the boards to lie flush with the face.

Cross garnet hinges should be used for hanging the door which, of course, opens outwards, and a thin strip of wood fitted to the inside face of the door post will prevent the door from being forced inwards and thus straining the hinges.

The Wire Netting may now be fixed to the inside faces of the framework, etc., and the door, using galvanised staples for the purpose.

Fix wire netting to the bottom part of the roosting-house, fastening a short length of chain to the top of the front sliding shutter and a hook for its reception to keep the shutter closed; screw in one or two screw-eyes for guiding the cord operating the trap-door, and fit either turn-buttons or padlocks to the doors and nest-box cover.

HOUSEHOLD STEPS AND LADDERS

One of the most useful household articles is a pair of steps or, as they are called in the north, step-ladders.

The most durable and convenient form for amateur construction is that shown in the illustrations in Fig. 1, where A is a side view, B a front view, C an elevation of the back member, and D and E are details of the treads and sides.

The ladder when open stands 5 ft. 4 in. high, so that the ceiling of any room in a small house can be easily reached from it.

The timber for its construction should be of the best quality yellow deal obtainable, entirely free from knots, shakes, and other imperfections. The side pieces and treads are ⅞ in. thick when planed or thicknessed and should be bought sized to finish. The back or strut member is ⅞-in. thick.

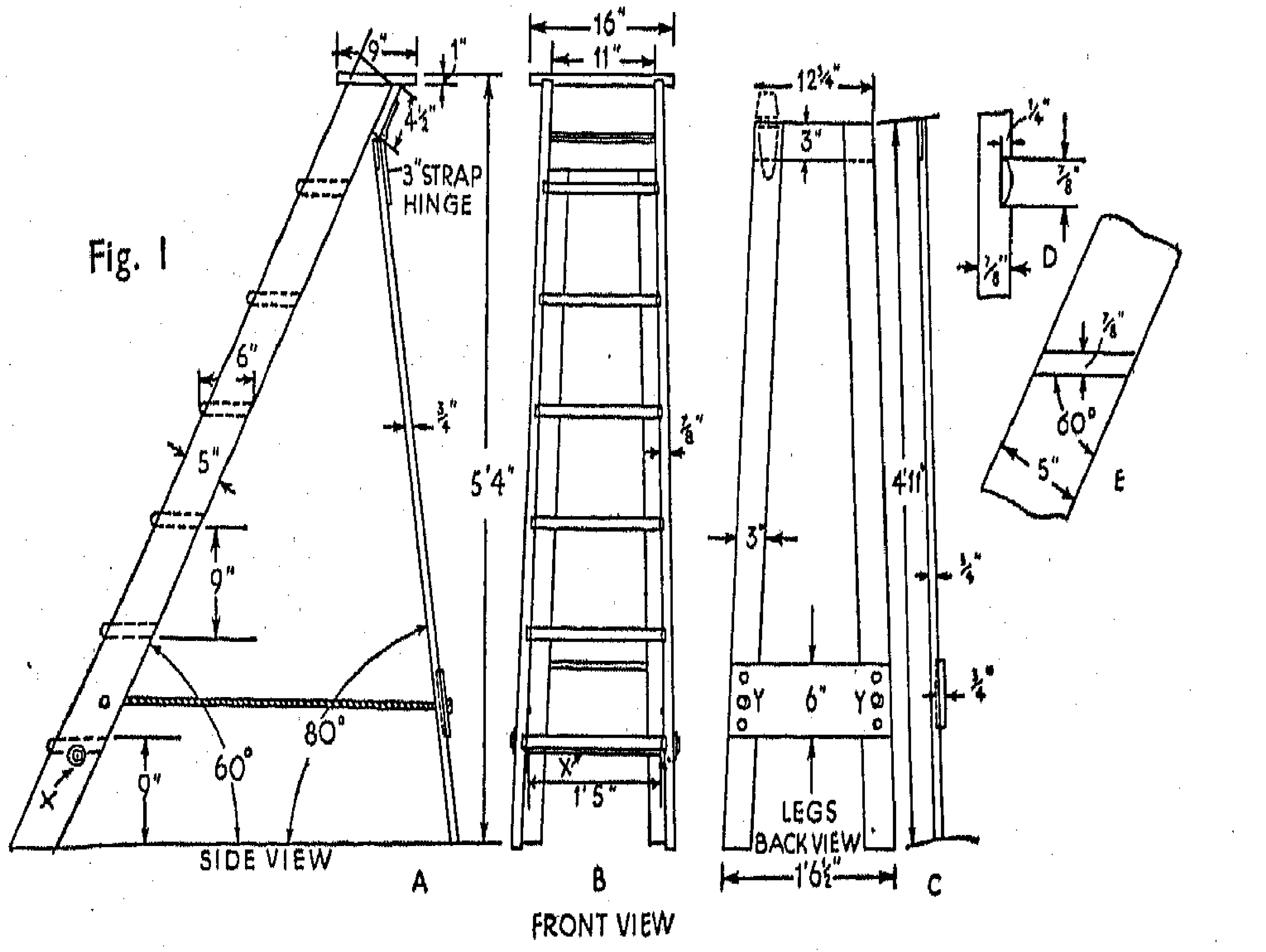


Fig. 1

Prepare the sides first. They are 5 in. wide by 6 ft. 3 in. long and provided with grooves to take the treads. (*See* E.) It is advisable to allow an extra 3 in. in the length to well inside the scribed lines, because the material for the treads may only be a bare ⅞ in. thick, and it is important that the ends of the treads should be a tight driving fit in the grooves.

Trim off the ends of the side-members to the same angle as the grooves, as previously marked, that is, 9 in. from the top of bottom groove and 9 in. from the bottom of the top groove.

It will be understood, of course, that the two sides are right- and left-handed respectively.

As the distance between the side-members is greater at the bottom than at the top, each tread must be made longer than its neighbour from the top downwards.

The Treads.—There are six (excluding the top board) and as the width between the sides ranges from 11 in. to 17 in. there will be a difference of 5 in. between the top and bottom treads, so that each of the five intermediate treads will be 1 in. less in length than its neighbour above. This gives the following widths between the sides—at the first tread (from the top) 12 in., at the second 13 in., then 14, 15, 16, and finally 17 in. at the bottom one. As the treads are sunk to a depth of ¼ in. in each side-member, ½ in. must be added to each length, so that the overall sizes will be 12½ in., 13½ in., 14½ in., 15½ in., 16½ in., and 17½ in. respectively The treads are 6 in. wide and ⅞ in. thick.

The Top Board is 16 in. long and 9 in. wide by 1 in. thick. It is recessed underneath with grooves ⅞ in. wide, stopped 1 in. from the front, to take the tops of the side-members. The front edges of the treads may be rounded or squared to choice, and all bevelled off at the back to 60° to lie flush with the back edges of the side-members.

The parts are assembled by laying one side face-upwards on the bench, inserting the top tread into its groove and then fitting the bottom one in a similar manner. The other side-piece is then placed on top and fitted. The next step is to square up these parts and fasten them together with three 1¾-in. clasp nails, driven through the sides into each end of the treads. Now place the frame on its back, drive the remaining treads into their respective grooves, keeping the back faces flush with the sides, and nail them in. Neatly bevel the projecting front corners, as shown in detail at D.

Now nail the top board on and then fix the back plate of ¾-in. stuff below the top board. This cross-piece is 4½ in. wide, square at the bottom edge and bevelled to 60° to fit close under the top board. It should be screwed securely into the sides and also held by means of screws driven through the top board, as it holds the legs.

The Legs are shown at C, which is a back view. All is of ⅞-in. prepared stuff, i.e. ¾ in. finished thickness. The top rail is halved into the tops of the legs, while the bottom one is 6 in. wide and is recessed at the ends. The shoulder fits against the inside faces of the legs and rests on the back of the legs, to which it is screwed.

Two strap hinges, 3 in. wide, of either wrought or stamped iron (not cast), should be screwed, with ¾-in. stout screws, into the back board of the steps and the top rail of the legs. They should be of the taper type, 4 in. long at the top and 6 in. at the bottom, as shown at C. If any difficulty be experienced in obtaining a hinge with leaves of different lengths, a 6-in. one could be cut down to the desired length.

The holes for cords can now be drilled in the sides and legs, and a piece of good quality sash cord fitted to each side and double knotted at each end. The length of the cords should be 4 ft. 2 in. between the knots, to allow the legs to be extended to their correct distance apart. When fitting the cords care should be taken to see that the bottoms of the step sides and legs lie level and square upon the floor.

In order to strengthen the steps and prevent any tendency of the sides to splay out from the treads, it is a good plan to fit a tension-rod underneath the bottom tread, as shown at X in A and B. This rod can be easily made of a piece of ½-in. round iron with a screw-thread at each end. Clearing holes should be bored in the side-members, the rod slipped through them and firmly secured with nuts bearing on iron washers.

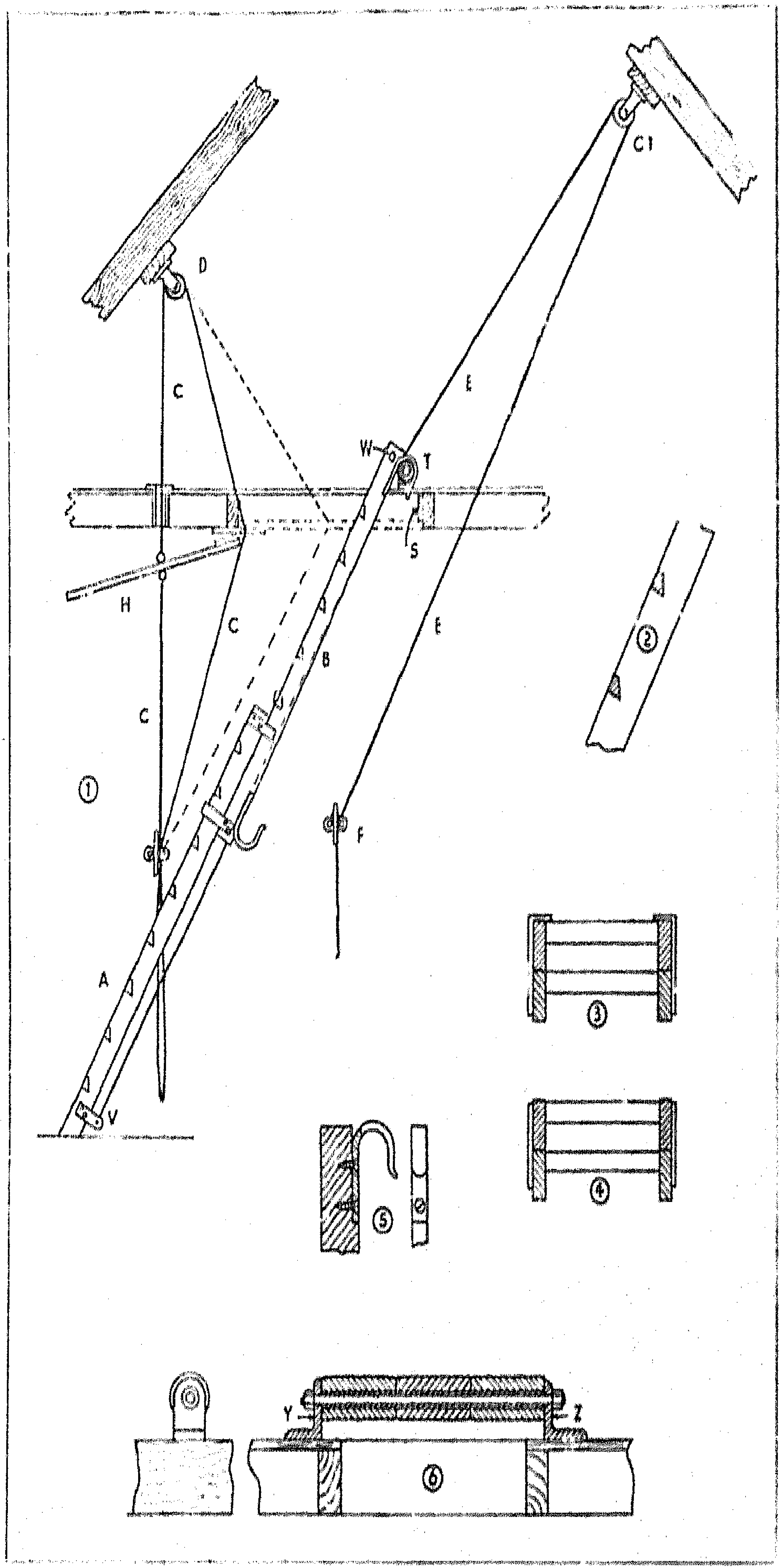
Obviously, the same method of construction can be followed for either longer or shorter step-ladders, but in cases of longer ones, it is advisable to make the legs of 1-in. thick material to avoid sag and twist due to the extra length and leverage. It is also a wise precaution to fit an extra tension-rod between the sides and under a tread at a distance of about two-thirds the length measured from the bottom.

A Loft Ladder.—Many a loft between the top-floor ceiling and the roof is unused because of the difficulty of getting to it. A loft ladder, which can be let down and pulled up again out of the way, will solve this difficulty. Such a ladder is easily arranged and constructed.

The drawings shown in Fig. 2 are not to scale, but will enable the reader to get an idea of the arrangement. The lengths and the position of the pulley will have to be made to suit particular situations.

The ladder is in two parts, A and B, of an equal length, the sides of which are made of good, sound timber ⅞ in. thick and 3 in. wide. The rungs are let into the sides, as shown at 2, the rung being wider at the back than the front and bevelled upwards from the back at the bottom so that the rung has a tendency to lie back to the ladder when weight is put upon it. This is a valuable safety device.

Both ladders are of the same width and one lies upon the other. Their sides are parallel and the rungs of the lower ladder are a trifle below flush with the



sides to enable the upper ladder to slide easily upon it.

To connect the ladders together so that they can slide one upon the other and yet remain firm when extended, ladder B has iron angle-straps, $\frac{1}{4}$ in. thick and $1\frac{1}{4}$ in. wide, screwed to its sides at the bottom and extending over the top ladder A, as shown in the section at 3. Ladder A has similar straps screwed to its sides at the top (shown in section at 4). It is not necessary that this strap should extend under B, since the tendency is to keep it down on B, and if returned it would cause an obstruction against the roller. These straps locate the ladders relative to each other and guide them as they are telescoped one on the other, when drawn up into the loft. Four curved steel hooks $\frac{7}{8}$ in. wide, of $\frac{3}{16}$-in. strip, are fixed to the ends of the ladder B. The hook has an inside diameter of 3 in.; details appear at 5. They are let into the narrow faces of the side-members and secured by means of three stout screws 1 in. long, with their heads well countersunk into the countersunk holes drilled in the shank of the hook.

Across the side of the trap-door opening a roller is fitted, as shown at 6. It is supported between two pieces of angle-iron, forming brackets Y and Z. These can be sawn with a hack-saw from any piece of angle-iron with a side 2 in. wide, and fixed to the loft floor or to boards fixed across the joists where there is no floor. The length of the roller must be 2 in. wider than the trap-door opening and it is made of three pieces of 2-in. iron barrel. The two end rollers should be 6 in. long, while the central piece will be of such length as, with the two end rollers, will make the overall length 2 in. longer than the width of the trap-door opening.

The three rollers are placed on a length of gas barrel, which fits easily in them, and the barrel is supported by an iron spindle whose ends fit into the holes in the brackets Y and Z, as indicated. They need not be an engineer's fit, but should be filled with grease. The reason for having three rollers instead of one is to allow the central roller to act as a frictionless guide for the operating cords.

The trap-door H should be taken off the top of the trap and trimmed to size to fit in the underside of the opening. It is hinged as shown to hang down, and is pulled up by a cord passing over a screw-on pulley D fixed to a convenient roof rafter. This cord is threaded through a hole in the side of the trap opening and can be fastened to a cleat fixed to the passage wall below the loft. A stop-piece S is nailed across the opening against which the door can be pulled up.

The ladder extended (with two rungs overlapping) should be of sufficient length to reach just above the roller down to the ground when at an angle of 60°.

In the loft, at a distance from the roller T, equal to the length of the closed ladder, a grooved pulley C, is fixed to a cross rafter or beam, or a cross board fastened across two rafters as shown.

A thin wire cable E, or a good quality plaited cord, runs up from an anchorage (which may be a cross bar) V at the bottom of ladder A and underneath its rungs and the rungs of ladder B, as indicated by the dotted line. It then passes over the central roller at T and up to pulley C, round it and back through a convenient hole in the ceiling and down to a cleat on the wall.

The action is as follows: The ladder being down rests with its top hooks on the roller and its foot on the floor. On pulling the end of the cable, the bottom of the ladder A is pulled up and slides along B until the top strap on A reaches a stop pin W projecting on each side of the ladder B, close to the top. Continuing, ladder B with A on top of it is pulled up until the hooks at the bottom of B engage with the underside of the roller. The cable is then secured tightly round the cleat on the wall at F. The trap-door is then pulled up by the cord C and all is neatly stowed away.

To Lower the Ladder release cord C from its cleat and let the trap-door H (shown closed by the dotted line) fall. Then pull the right hand bight of the cord till the slack is taken up round pulley D and the trap-door is pulled up into the position shown, so as not to obstruct passage up the ladder. Secure both sides of the bight round the cleat. Dotted lines show the position of the cord when the trap-door is closed. Next, release cord E from cleat F and let the ladder run down the rollers to the ground.

In cases where the roof is not high enough to obtain the necessary angle to start the ladder down by its own weight when released, a thick cord will have to be fastened to the bottom of the ladder and pass through a hole in the trap and be of sufficient length to be looped down and caught when the trap is lowered.

RADIO CABINETS

THE making of cabinets for radio receivers and loud-speakers offers exceptional possibilities for the ingenuity of the amateur craftsman who is interested in cabinet-making.

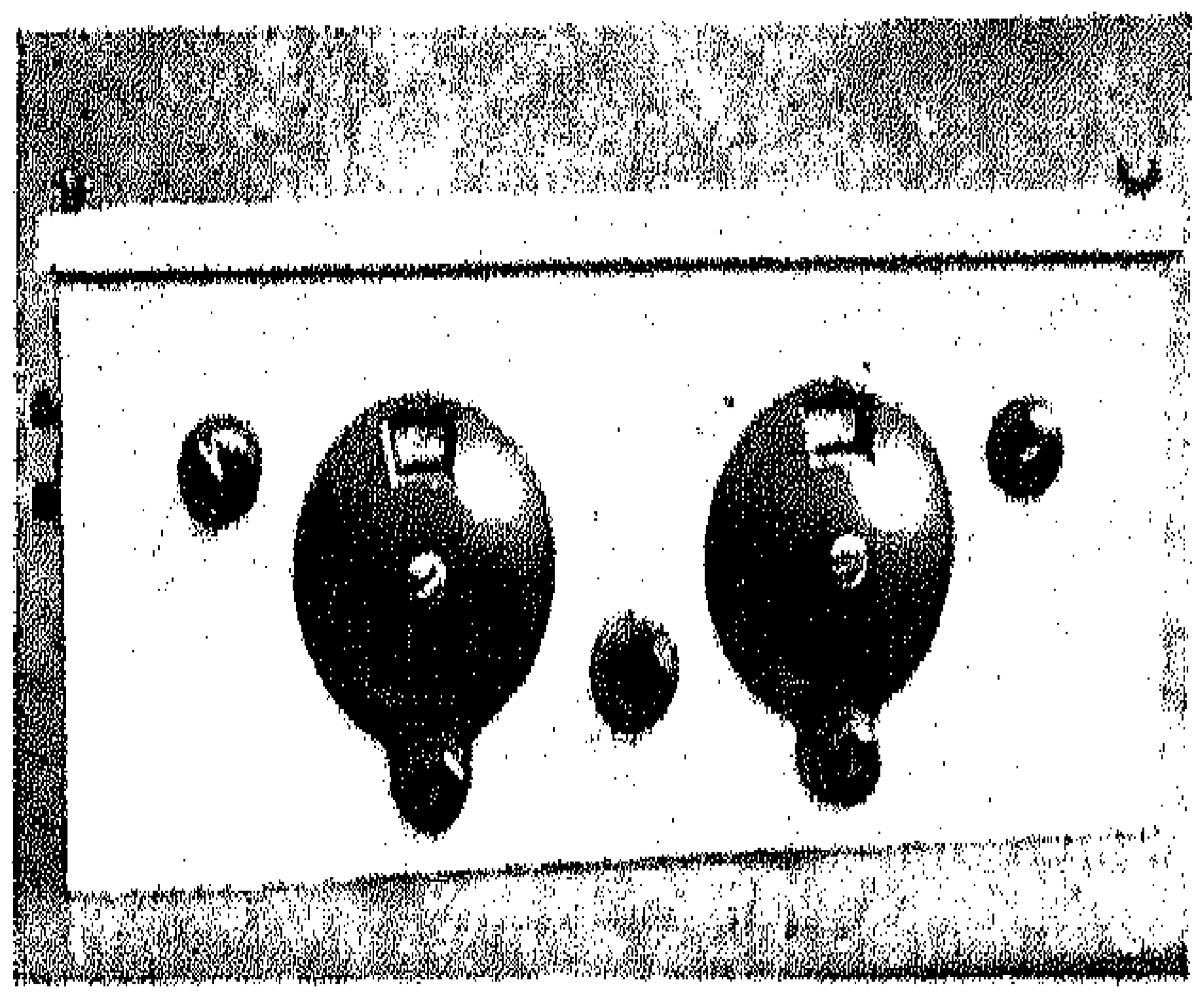


Fig. 1

A very simple and inexpensive type of cabinet suitable for housing a three-valve set having an external loud-speaker is represented in Fig. 1. The cabinet is sufficiently large to accommodate the high-tension and low-tension batteries.

The base, sides, back and lid consist of plywood ⅜ in. thick, while the front is of similar material $\frac{3}{16}$ in. in thickness. The latter is supported at the top by means of a horizontal piece of stripwood of ⅞ in. by ½ in. section. The sides of the lid are made from stripwood, ⅝ in. wide by $\frac{3}{16}$ in. thick.

To construct the cabinet, mark and cut out all the parts to the dimensions shown in Fig. 1, in Working Drawing No. 12, presented with this book, and assemble the pieces, using brass countersunk-headed screws for the purpose. It is advisable to fix the sides and front of the lid with glue and fine panel pins, after which the top edges can be slightly rounded with the aid of glass-paper.

Before fixing the front of the carcass—which should be fastened with screws driven into the top rail, sides and base—the holes should be located and bored to receive the spindles of the various controlling knobs of the receiver.

A pleasing finish, contrasting well with the black dials, as shown in the illustration, is obtained by using white gloss enamel in lieu of the more orthodox french polish. Before applying the enamel, all screw-holes should be filled with plastic wood and the whole of the exterior of the cabinet thoroughly smoothed with fine glass-paper. Two undercoats of white, thin, flat paint should first be applied.

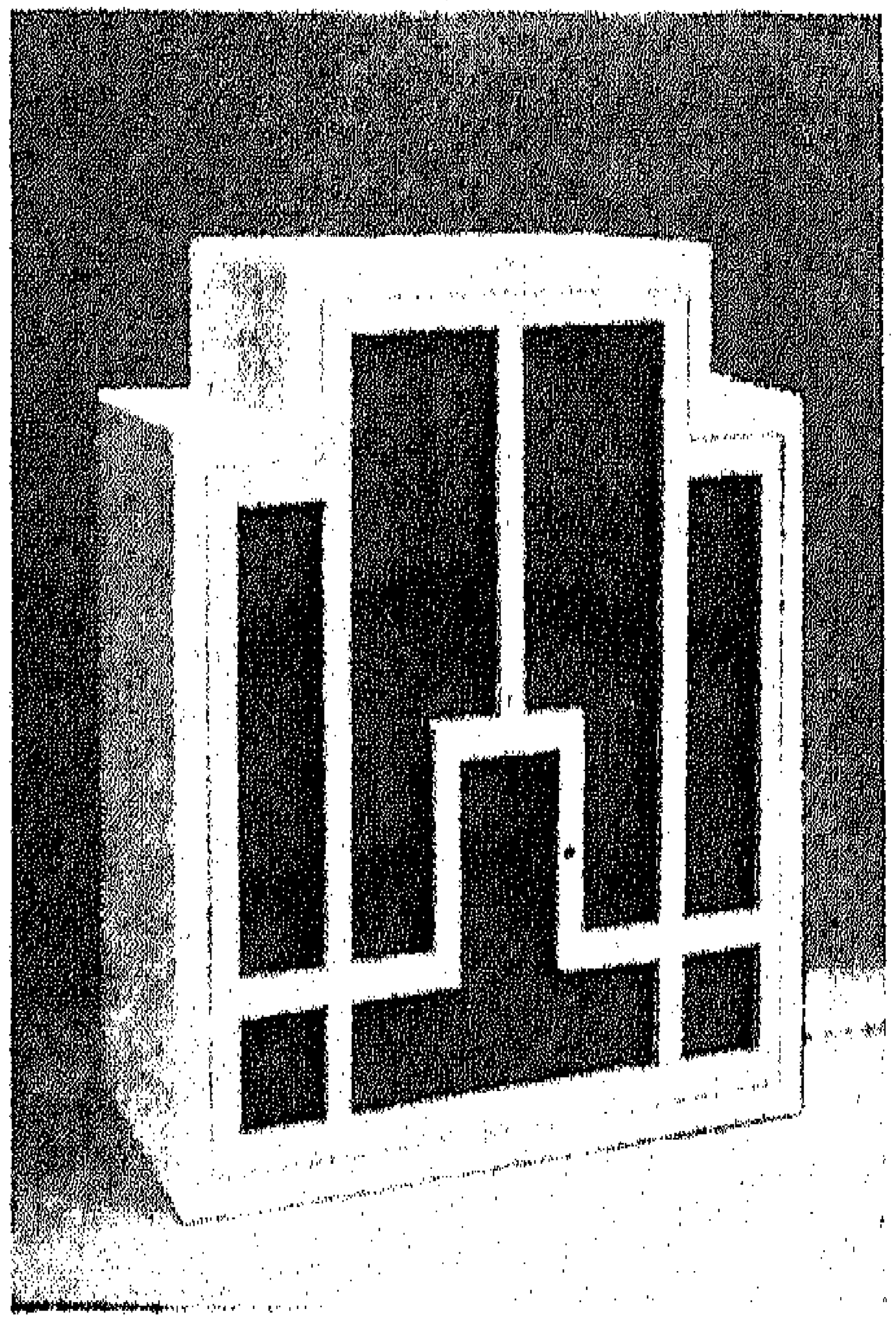


Fig. 2

The Loud-speaker Cabinet represented by Fig. 2 is of a suitable design to match the receiver fitment just described, and is of sufficiently large dimensions to accommodate a modern 8-in. diameter moving-coil speaker unit.

The carcass is finished in white enamel, with the exception of the overlay of the fret, which could be enamelled in black. This feature not only relieves the plain effect of a single colour, but greatly enhances the appearance of the cabinet.

Like the receiver cabinet, the carcass is built of ⅜-in. plywood, dimensions of which are shown clearly in Fig. 2 in the Working Drawing.

The actual construction is quite a simple and straightforward job, and therefore calls for little explanation. The use of triangular-section strips, glued at the corners, adds considerably to the strength. The fretted front shown in the elevation should be accurately cut out with an ordinary fretsaw, and then ½-in. by ⅛-in. overlay strips pinned and glued over the outline. Before fitting the front to the carcass, a piece of loud-speaker fabric, obtainable at most radio stores, is glued to the back of the fret. A ⅜-in.-thick baffle-board, having a hole cut in it to suit the speaker unit, is then screwed to ½-in. by ½-in. fixing-blocks fastened to the sides of the cabinet as shown.

A Radiogram Cabinet.—Fig. 3 shows an illustration of an amateur-built radiogram cabinet which is a particularly handsome piece of furniture.

The cabinet is divided into three compartments; the top one for accommodating the gramophone turntable and pick-up; the middle one for housing the receiver; and the lower compartment for taking the loud-speaker, batteries, etc.

The fitment consists mainly of oak-faced plywood, supported in a framework formed by the legs and rails.

The legs are of oak and are 3 ft. 3 in.

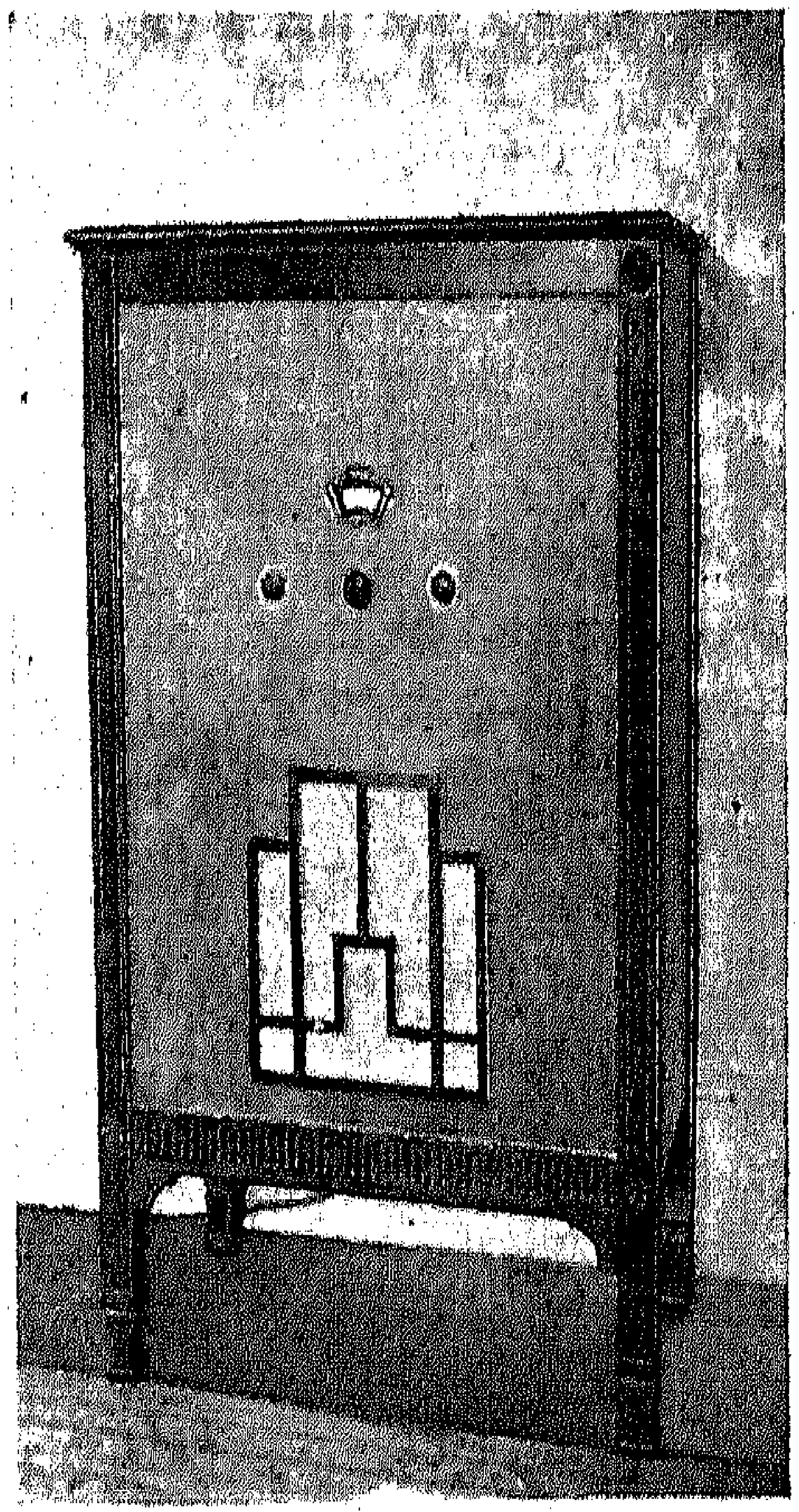


Fig. 3

long by 1½ in. square section, a section sufficiently robust to allow of the making of strong mortice-and-tenon joints or, if preferred, dowel joints. The rails are of the same section, except the top back member, which is 5 in. by 1 in. Oak-faced plywood ½ in. thick is used for the lid, the unsightly laminated edges of which are hidden from view by means of ½ in. half-round section edge-moulding.

The door at the back is merely a framework upon which loud-speaker fabric is stretched and glued. A solid wooden door should not be employed, as it greatly reduces the tonal quality of the loud-speaker by imparting a muffled effect.

To make the Cabinet, start by sawing, planing and marking out the legs and rails to the dimensions given in Fig. 3 in the Working Drawing. It is best to make the top ends of the legs an inch or so longer than the finished sizes, as the extra material will enable the mortices to be cut without risk of splitting the wood. The surplus can be sawn away after the parts have been fitted.

Having completed the mortices in the legs and the tenons on the rails, the next procedure is to plough the ½-in. deep grooves to accommodate the side panels, and to cut the 5-in. wide and ½-in. deep recesses in the back faces of the rear legs, to take the top back rail, which is half housed into them.

Assuming that the parts are ready for assembly, start by gluing the side panels into their respective channels in the legs and rails and at the same time glue and fit the joints. Then cramp up the sides, test for squareness, and if correct, put the two members aside for the time being to allow sufficient time for the glue to harden. Next glue and fit the front and back rails to the sides, reinforcing the top back-rail joints by means of 1½-in. No. 10 countersunk-headed screws, taking care to keep everything square.

When sufficient time has elapsed to ensure that the glue is dry, fix a ½-in.-square section fillet round the two side faces and top of the front opening to form a fixing for the front panel. Fasten the fillets with No. 6 screws, 1 in. long.

The next items to receive attention are the shelves and door. The lower and middle shelves can be made of ⅜-in. birch plywood, which is considerably cheaper than oak-faced stuff, but the top shelf should be of the latter material. The bottom shelf or floor is supported by and screwed down to the projecting edges of the rails. The corners of the shelf will have to be recessed to allow the corners of the legs to clear. The front edge of this shelf should lie flush with the front of the side fillets, as the edge forms the bottom fixing for the front panel. Cross-pieces of ¾-in.-square section planed deal, screwed to legs, are used for supporting the other shelves. The distances between the shelves are, of course, determined by the depth of the gramophone equipment and the receiver. Quite a satisfactory door can be made by using 2 in. by 1 in. planed deal batten, dowelled and glued at the joints.

The Front Panel is ¼ in. thick. Holes should be bored to accommodate the spindles of the controlling knobs, switches, etc., and a number of holes drilled near the edges to take the fixing screws, which should be ¾ in. long, of the brass, round-headed type. A fret having a stripwood overlay is made in the lower portion of the panel. Dimensions for the fret can be taken from Fig. 2 (Working Drawing).

The remaining operations consist in hingeing the lid and door and glass-papering the whole of the external surfaces prior to staining and wax-polishing. A good effect is obtained by finishing the carcass a Jacobean oak colour and the front panel a light shade of oak.

USEFUL CUPBOARDS

CUPBOARDS are very necessary in every house and can be easily built by using the corners and recesses of the walls.

Recesses at the sides of chimney-breasts in bedrooms and kitchens are easily made into handy cupboards without having to build a very complicated framework—the walls providing a substantial fixing.

Such cupboards, being nailed or otherwise fixed to the building, become what are known as "landlord's fixtures," and may not, therefore, be taken away if the tenant leaves. If the householder is the owner of the premises he will, of course, be able to do as he likes. But even with the chance that the landlord may eventually claim the cupboards, they are well worth fixing, as they are easily constructed with inexpensive materials.

A Cupboard in a Recess.—Fig. 1 in Working Drawing No. 13 shows a useful type beside a chimney-breast. It is 6 ft. 6 in. high and 3 ft. 6 in. wide; the width, of course, depends on the width of the existing recess and the timbers must be cut to suit. In Fig. 2 a view is shown of the battens which support the shelves, the top member A holding the ½-in.-thick boards which form the top or cover. The battens are 5 in. wide and prepared from ¾-in. stuff, and the top member and shelves are of ½-in. deal nailed on to the battens.

As the chimney-breast is always constructed of brickwork, the wall should be plugged and screws used for securing the battens, but the wall opposite the side of the chimney-breast may consist of a lath-and-plaster partition, in which case the battens can be fixed by means of screws driven into the wooden "studs" or upright members of the wall, which are usually spaced from 14 in. to 18 in. apart.

In order to find the positions of the studs—which, of course, are invisible—take a light hammer and gently tap along the partition. The space between the uprights will sound hollow and the hammer-head tend to spring from the surface, while the sound produced when tapping on a stud is dull and it presents a solid resistance to the hammer. The position can then be verified by inserting a fine bradawl. Care should be taken not to damage the plaster by hammering too hard.

The door is surrounded by a framing of 4 in. by ¾ in. deal and can conveniently be 6 ft. 6 in. high. There is no bottom cross-member to the frame, the door extending down to the floor, which allows the bottom of the cupboard to be easily cleaned.

The top rail is halved into the side-members as shown at B in Fig. 3, and, to make a neat finish, flat strips, as indicated at C, 2¼ in. wide, with bevelled edges and mitred joints at the top corners, surround the frame and are fastened to it by means of short oval wire brads. The overlay partly hides the longitudinal joints of the halved uprights and sides and is shown in section at C. The outside edges of the frame uprights are cut at the bottoms to fit the skirting board, as shown at D in Fig. 3, and the skirting boards round the recess are used to support a shelf of ⅝ in. stuff, below which shoes can be conveniently stored.

The frame beds up against the ends of the side battens shown in Fig. 2 and, in order to hold it firmly, one or other of the two fixings illustrated in Fig. 4 can be used. At D in Fig. 4 is shown a staple fixing. The staple (F in Fig. 4) has a tapered shank to drive between the bricks or into the wood. The circular-shaped end fits against the back of the frame and has a screw hole through which a screw is driven to secure the frame. Staples of this type can be obtained at most ironmongers, and are quite inexpensive.

The other fixing, shown in sectional plan at E in Fig. 4, is particularly suitable for a lath-and-plaster wall. A vertical post (G) is fixed to a stud by means of screws driven through the plaster, and the door-frame nailed up against it. A strip, H (Figs. 3 and 4), 3 in. wide and ¾ in. thick, is nailed around the back of the frame so that it projects ½ in. beyond the edges to act as a door-stop.

The door-frame should be made up of ready-planed deal. The halved top corner joints should be well fitted, glued and screwed together from the back, using stout screws ⅝ in. long. The frame should exactly fit the recess in width and should be temporarily held square and parallel by means of a batten nailed across the uprights at the bottom and strips lightly fastened diagonally across the uprights and the top rail to prevent the joints from springing out of position.

To fit the frame, it should be held temporarily in the recess by inserting thin slips of wood or wedges and set to vertical lines previously marked on both walls with a pencil and the aid of a plumb-line. The staples or the fillets (Fig. 4)—whichever method of fixing is adopted—are then fixed to the walls and the frame screwed to them from the back in the case of the staple fixing, and nailed through the front where the fillet fixing is employed.

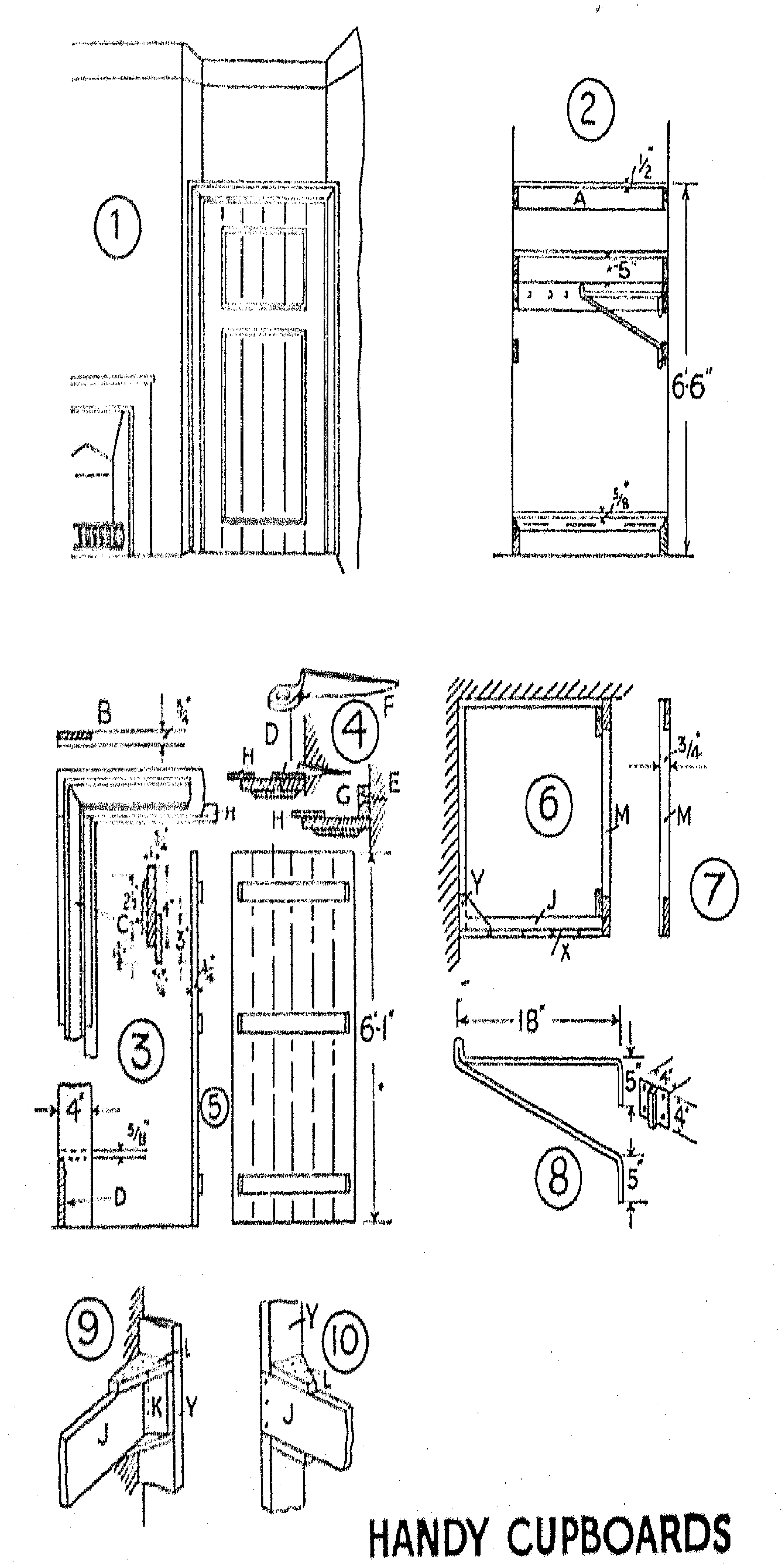
The door shown in Fig. 5 is of the plain ledged type. It can be made of 6 in. by ⅞ in. plain matched boards, i.e. without any ornamental bead at the joint, fixed together by means of three 4-in. by ⅞-in. battens. The boards should be temporarily held in position with thin strips of wood and fine wire nails and then cramped up tightly together. While cramped, the cross-pieces should be screwed securely from the back by using three stout screws at each joint. The width of the door will be the width of the framing plus ⅛ in. for planing to fit—afterwards.

The front of the door should be carefully smoothed with a sharp plane and then glass-papered. The addition of a standard moulding, half-round in section and about ⅜ in. wide, fixed to the face of the door to imitate panelling, will greatly improve its appearance. The beading strips should be neatly mitred at the corners, glued at the back and further secured by means of fine brads. The design is shown in Fig. 1, but any design of false panelling can be used to the choice of the maker.

The door is hung on two 2 in. cast butt hinges, recessed half in the frame and half in the edge of the door and arranged to open either hand, whichever is most convenient, although it is the usual practice for such doors to open against the wall.

Shelving can be fitted to suit individual requirements, but since the cupboard is 6 ft. 6 in. high there is ample room for a shelf 15 in. from the top. Such a shelf is handy for storing suitcases, hats, etc.

Below this shelf, side battens or rails of ¾ in. stuff, 5 in. wide, may be added. There should be two of them each side and one across the back. The upper set should butt up against the shelf batten and have a back batten for pegs. The under one should be 5 in. below the upper one. They hold the swivelling brackets which support the upper and lower members of the swing-arms used



HANDY CUPBOARDS

WORKING DRAWING Nº 13

for suspending folded clothes (shown at Fig. 2).

The Brackets are made of $\frac{3}{16}$-in. iron rod, bent to the shape and dimensions shown, while the sockets for supporting the brackets are made by bending pieces of thin brass plate 4 in. deep and 4 in. wide when bent, as shown in detail in Fig. 8. The vertical ends of the brackets slip into the sockets and provide a substantial swivelling support. Four such brackets fitted on each side of the cupboard will give plenty of accommodation for hanging clothes.

Where a recess is not available for the construction of a cupboard, a corner fitment made on similar lines to the one just described can be used to advantage. Fig. 6 shows a plan view of the arrangement.

The Door-frame is of the same construction as the recess cupboard, and the door can be made to either wall, i.e. the cupboard may face in either of two directions. Battens (as in the recess cupboard) are nailed to the walls, and the outstanding side of the cupboard x, is of matched boards nailed to battens secured to a vertical post y, which is screwed to the wall. As the side of the fitment has no outer support, the arrangement shown in Figs. 9 and 10 is used at the wall end of the battens. The side batten J is let into the wall-post y, at the back of which is nailed a rectangular piece of wood K, 1 in. thick and the same length as the width of the batten, J. The end of the batten is nailed into the recess in the post and, to strengthen the joint, triangular pieces are nailed to the batten J and the bearer-plate K. This makes a good, strong fixing to the wall.

The front frame M (Fig. 6) is exactly the same as that employed in the recess cupboard, and is halved into the top rail. It has, however, an additional rail, M, at the bottom, the same width as the top one and halved in the same way. This extra rail is to keep the projecting side of the cupboard perfectly rigid. This rail is shown in Fig. 7 and is of $\frac{3}{4}$-in. material. The door is exactly the same as the one previously described.

Shelves are supported on battens as in the cupboard (Fig. 2) and hangers are fitted in; to make the structure more rigid, the shelves should be screwed in from the outside of the side x and on the battens or bearers on the opposite wall.

The top member is made of material $\frac{3}{4}$ in. thick. The side x, should be screwed to four battens or rails J—one at the top and bottom and two equally spaced between.

The exterior of the cupboard should be carefully smoothed with glass-paper and all knots treated with knotting to prevent the resin from spoiling the surface when finished. A priming coat of paint followed by two further coats should then be applied; the latter to match the decorations of the room.

BEDROOM FURNITURE

THE construction of the chest of drawers shown in Fig. 1 follows very simple lines. Oak-faced plywood plays an important part in its construction, with pleasing effect.

To make the chest of drawers, four legs are required, each 2 ft. 5½ in. long, cut from 1¼-in. square (finished) oak, as indicated in Fig. 2. The two back legs are grooved ¼ in. deep and $\frac{3}{16}$ in. wide as shown dotted in Fig. 2, to take the plywood panel, which is 18⅞ in. from the top to the bottom edge, including ¼ in. let into the groove in the

under edge of the top rail and the groove in the upper edge of the lower one. The front legs are grooved on one face only to the same width and depth as the back ones. The size of the side panels is 18⅞ in. long by 14⅜ in. wide overall.

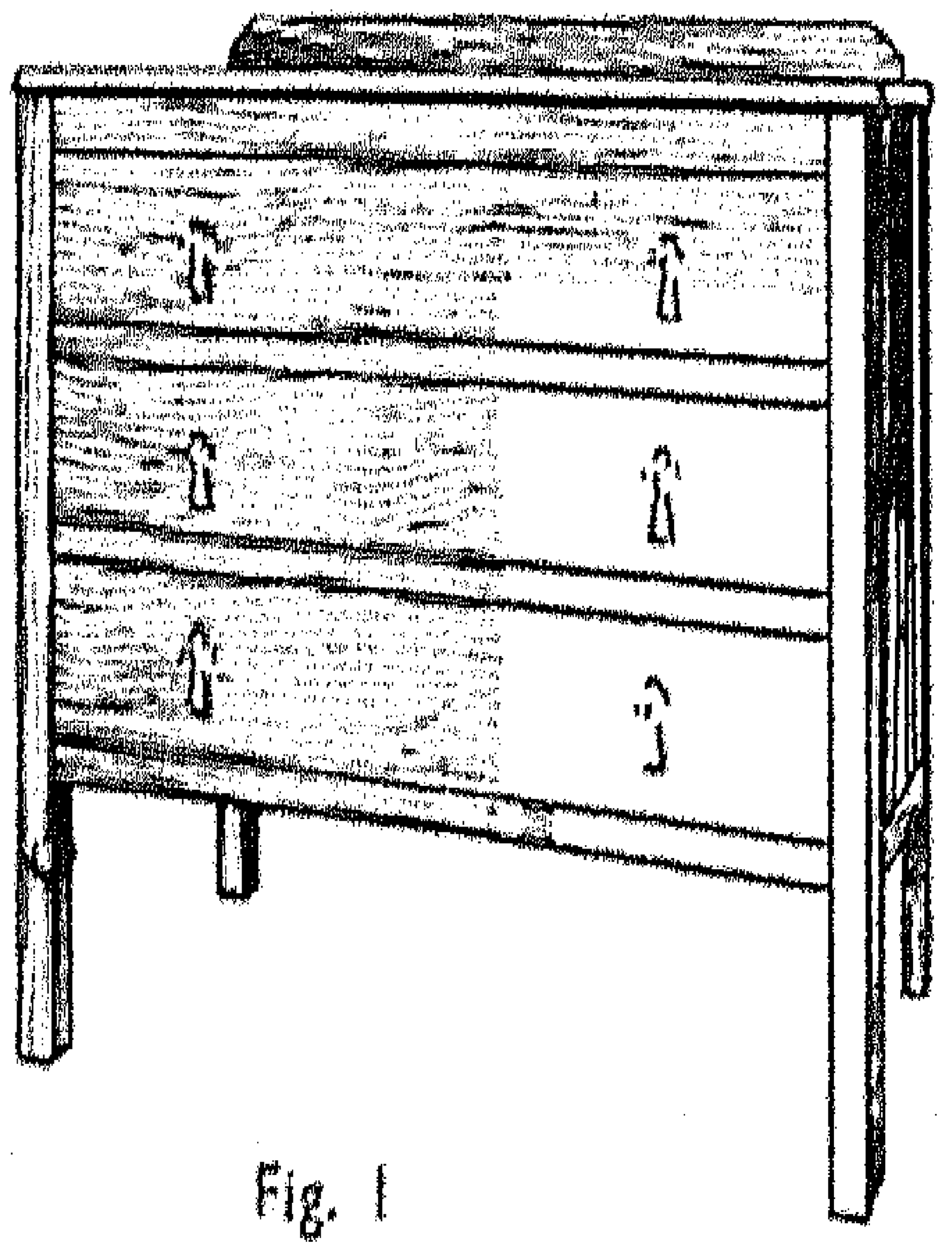


Fig. 1

When preparing the legs do not attempt to true up more than the faces which butt against the ends of the rails; if these faces are dead square there is no need to worry too much about the outer faces.

The legs are secured to the rails by means of dowel pins, one at each end for a narrow rail and two for the wider ones. The back vertical piece is also dowelled. The diameter of the dowel pins is ⅜ in. When marking out the holes and dowel positions, care must be taken that those in the side rails do not run into those in the back rails. Do not forget to make a small groove down the length of each dowel before fixing, to allow any surplus glue to escape.

Each of the three dividing rails across the front opening is ¾ in. thick by ⅞ in. wide, fixed with the ¾-in. face to the front. Flush with the top surface of each of these rails ⅝-in. square fillets are fixed to the sides of the legs at both sides. Each fillet has a strip of plywood tacked to the outer side and between the faces of the back and front legs and arranged to project ⅛ in. above the surface of the runner to act as a guide for the drawer.

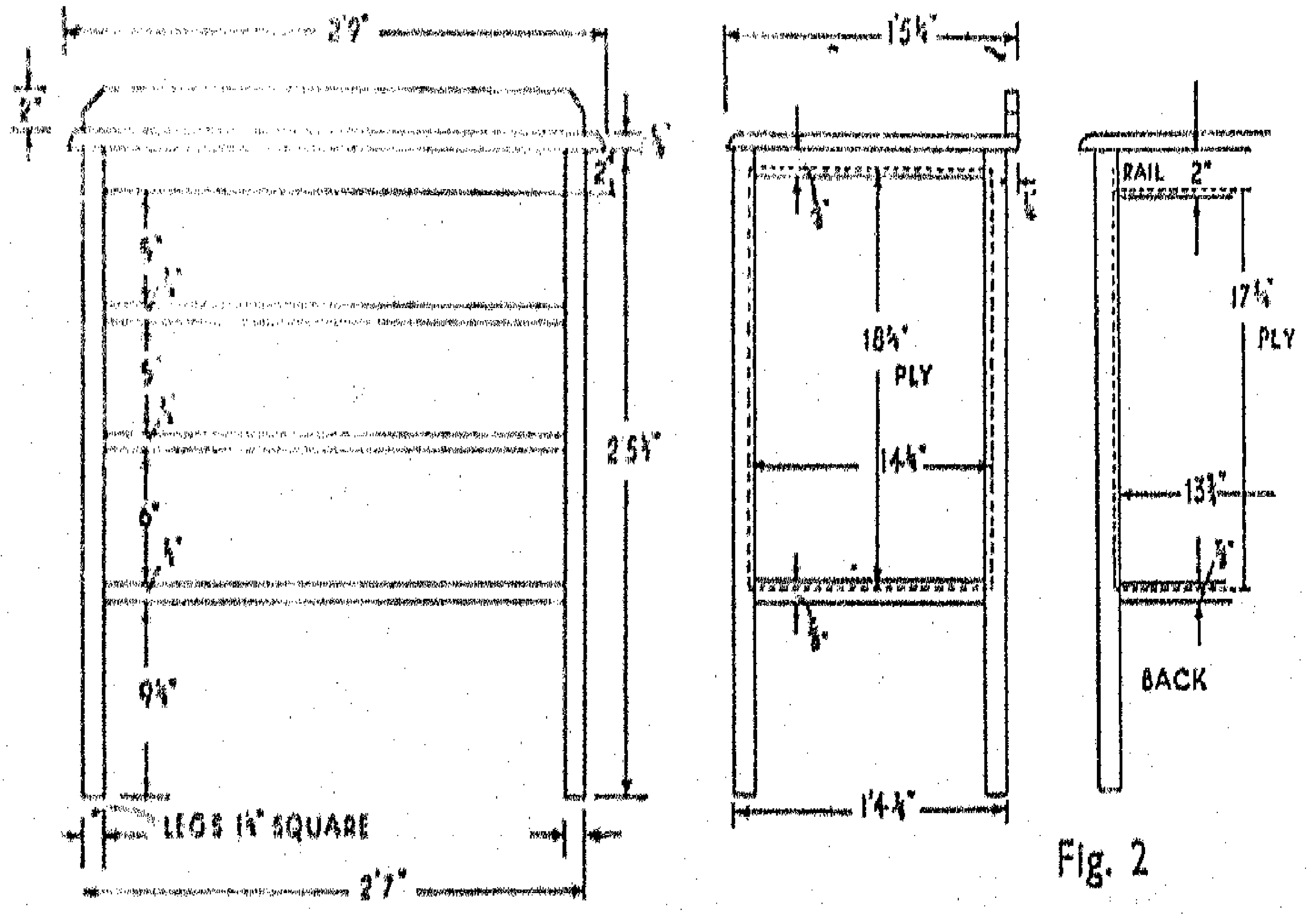


Fig. 2

The plywood for the back is in two sections, each measuring 17⅞ in. long by 13⅜ in. wide overall, divided by a vertical piece of wood 2 in. wide, grooved ¼ in. deep, $\frac{3}{16}$ in. wide, in both edges. This vertical member is fixed midway between the back legs and to the top and bottom back rails.

The only difference in the sizes of the drawers is an extra inch on the depth of the bottom one. The fronts and backs of the drawers are ¾ in. thick, 2 ft. 4½in. long by 5 or 6 in. as required, rebated at the ends to take the sides. The sides are ⅜ in. thick and grooved ½ in. from the lower edges to take the edges of the plywood bottom. Fillets of ½-in. square wood are pinned and glued to the front and back below the bottom panel to support the long edges of the plywood. Six drop-handle fittings, or the more modern rectangular-shaped wooden ones, will be required, and locks may be fitted if desired.

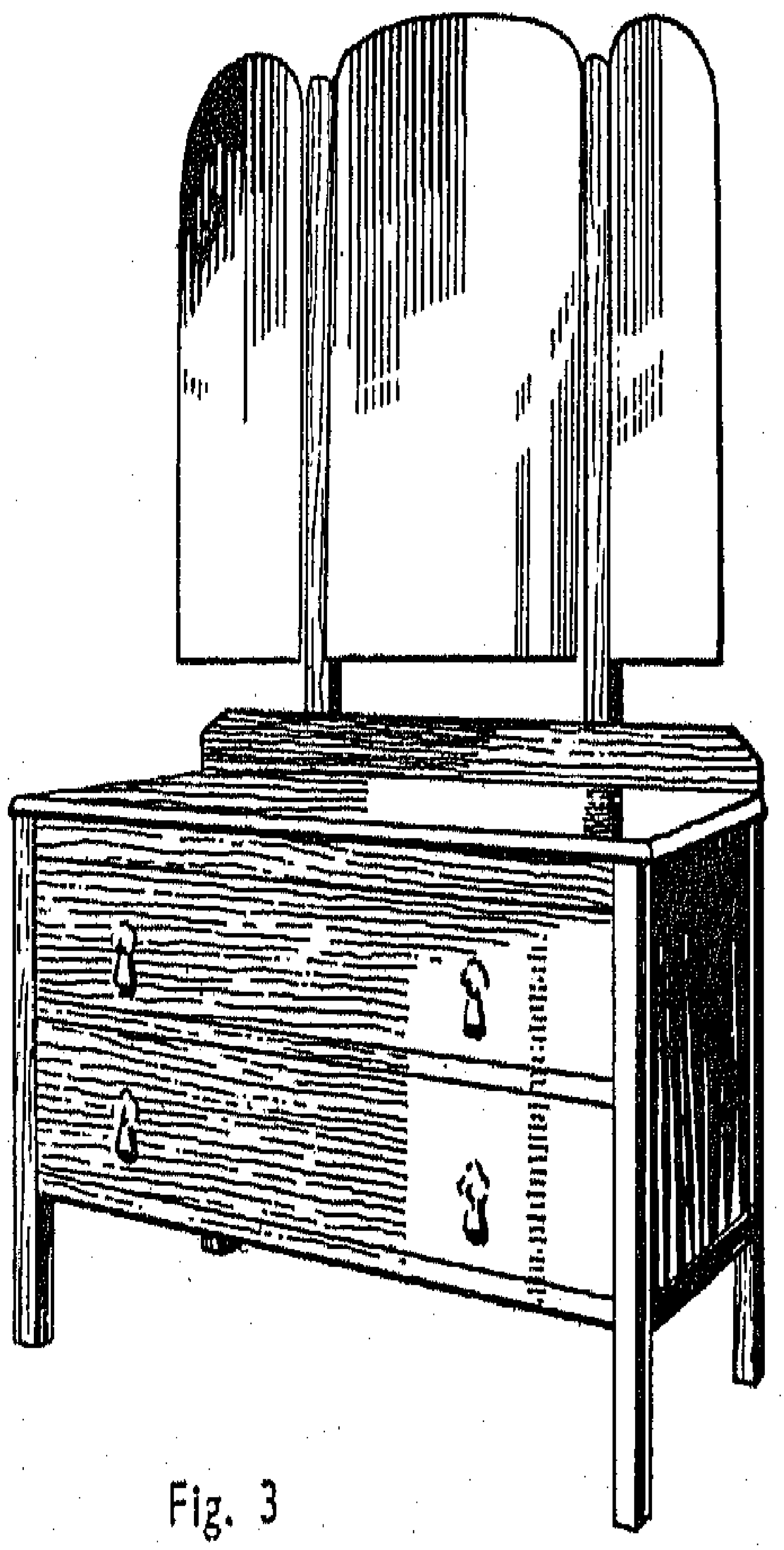


Fig. 3

When assembling, the two ends can be finished complete with ply panels and drawer runners in correct position and the back made up into a complete unit. The top rail and drawer divisions can be eased into position on one side, the back unit treated in a similar manner and the other end-unit added last.

The top oak boards should be glued up, cramped and allowed to set before the edges are rounded off. The brads or small-headed screws used to fix the complete top to the body should be sunk well below the surface and the holes filled in with plastic wood. The surface should then be well rubbed down with glass-paper.

For finishing, a prepared grain-filler may be used, followed by two or three applications of brush polish.

The Dressing-table shown in Fig. 3 and Working Drawing No. 14 is made on similar lines and has $\frac{3}{16}$-in. plywood panels let into the grooved faces of the legs. Dowels are used for joining the ends of the rails as in the chest of drawers.

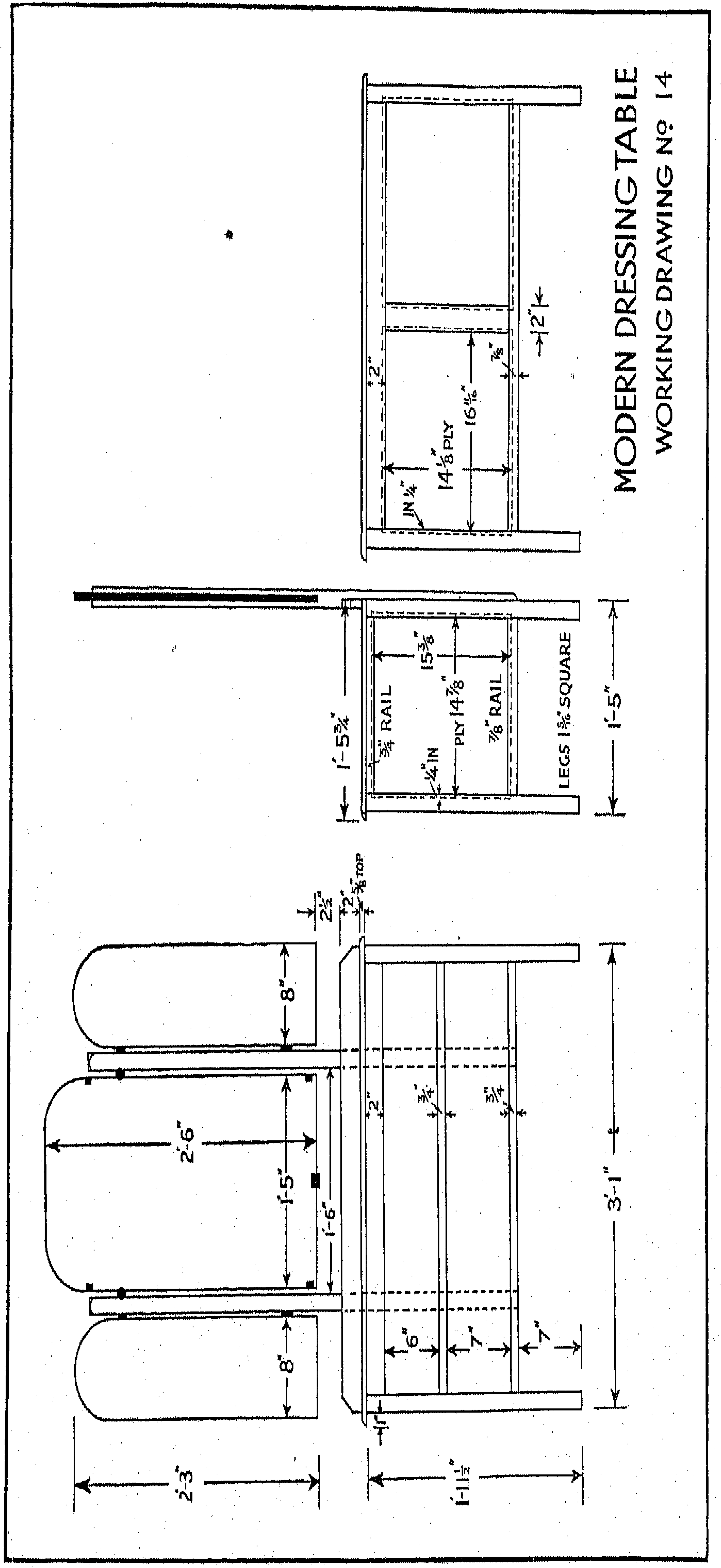
The back edge of the top does not overlap, but is flush with the back face of the legs so that the two vertical supports for the mirrors can be carried down the back as far as the bottom rail and secured by means of screws to the two rails. The lower part of the front edge of each support is cut away to the thickness of the backboard.

The mirrors are frameless and have bevelled edges. These are backed with plywood and are held in position by means of metal clips. The swivel movement for the centre mirror and suitable hinges for the side ones, as well as the mirrors themselves, can be obtained at most stores dealing in furniture fittings.

A Wardrobe to match the dressing-table and chest previously described is illustrated in Fig. 4 and the Working Drawing No. 15.

Large cupboard space is provided, a deep full-length drawer and a mirror. The wardrobe is made in two parts, the upper portion of which is detachable from the lower or drawer section.

The drawer section consists of two end frames formed by the legs and rails.


MODERN DRESSING TABLE
WORKING DRAWING No 14

the intervening space being filled with oak-faced plywood. The legs are of 1¾-in. by ¾-in. oak, grooved to take the edges of the panels, as also are the side member rails and the top and bottom longitudinal rails, which connect the end members together.

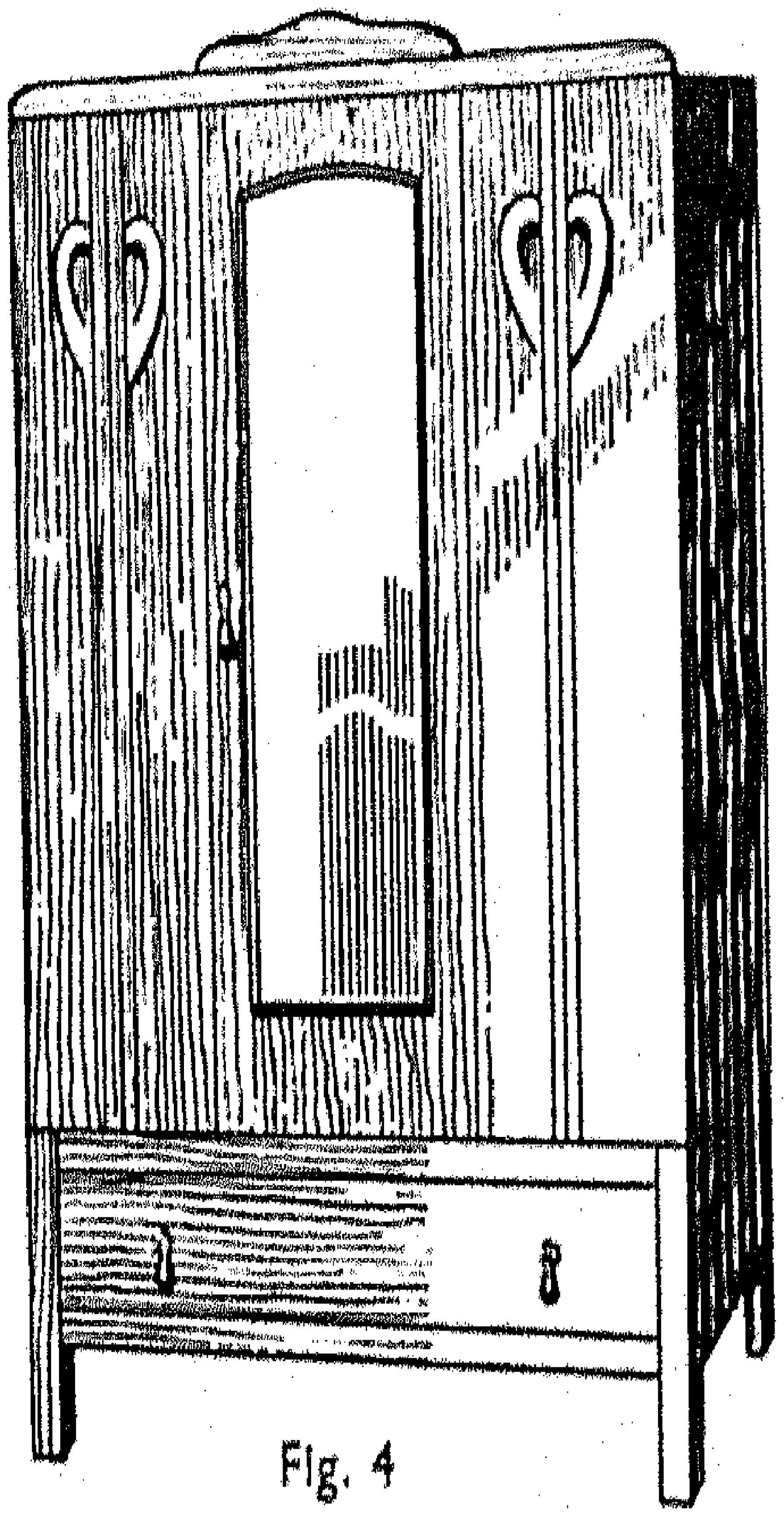


Fig. 4

All top rails are 2 in. wide by ¾ in. thick, while the lower ones are of similar thickness, but 3 in. wide. The joints used are simple dowel joints and ⅜-in. diameter dowel pins are employed. One dowel pin is used at the end of each top rail and two at the ends of the lower rails, as shown clearly in the front view.

An extra vertical member 2 in. wide by ¾ in. thick between the top and bottom back rails divides the plywood into two panels each 26¾ in. by 8½ in. wide overall. Side runners for the drawer are fitted to the inside faces of the legs. One or more cross-pieces may be added across the width of the opening and dowelled into the front and back rails to give additional strength.

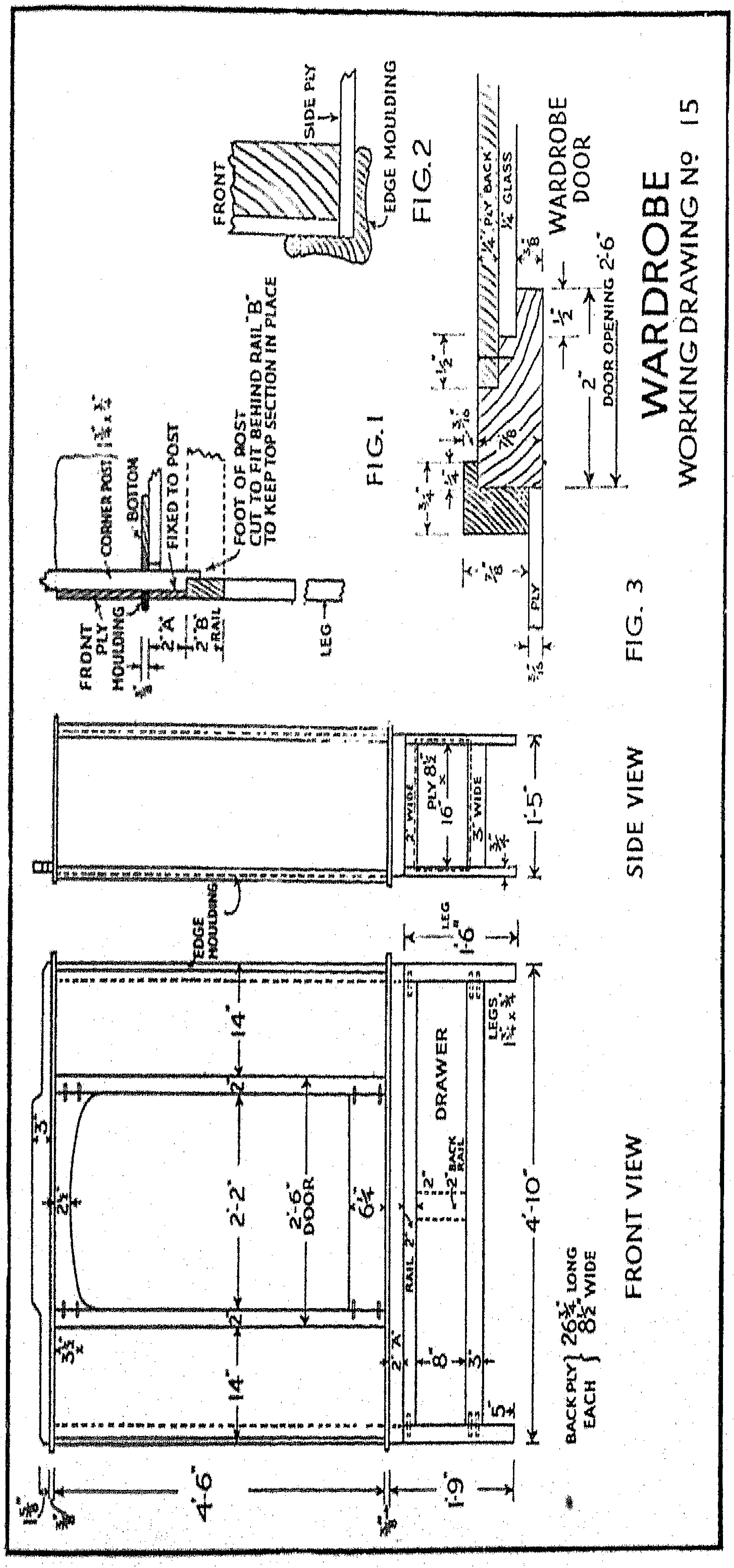
The drawer is made on similar lines to those described in the article dealing with a chest of drawers, but the plywood bottom should not be too thin and extra bearing strips fixed underneath across from back to front will give further support. The cupboard section consists of four corner posts of 1¾-in. by ¾-in. oak supporting the top, which overlaps all round.

At the lower ends the posts are cut to allow the back to pass behind the top front and back rails of the drawer section and thus keep the top section in position. This is shown in detail in Fig. 1 in the Working Drawing. The piece A is a strip of plywood 2 in. wide fixed to the uprights below the moulding, with its front face flush with the front of the top rail B of the lower section. The sides and back are treated in a similar manner and the main plywood panels forming the back, sides and front are screwed to the uprights. Lengths of corner moulding are fitted down all four corners to hide the edges of the plywood and the fixing screws as shown in detail in Fig. 2.

Extra vertical members are fixed behind the plywood front between the cupboard floor and the top to give support at the edges of the door opening. These are cut from ¾-in. by ¾-in. material planed to leave a projecting fillet ½ in. by 3/16 in. to act as a door-stop.

As an alternative ⅞-in. by ½-in. planed batten could be used for the door uprights with a strip of wood to form the ½-in. by 3/16-in. rebate as a separate piece, secured by means of screws. The floor boarding is supported on bearers screwed to the inside faces of the posts and cut away where necessary to clear the posts.

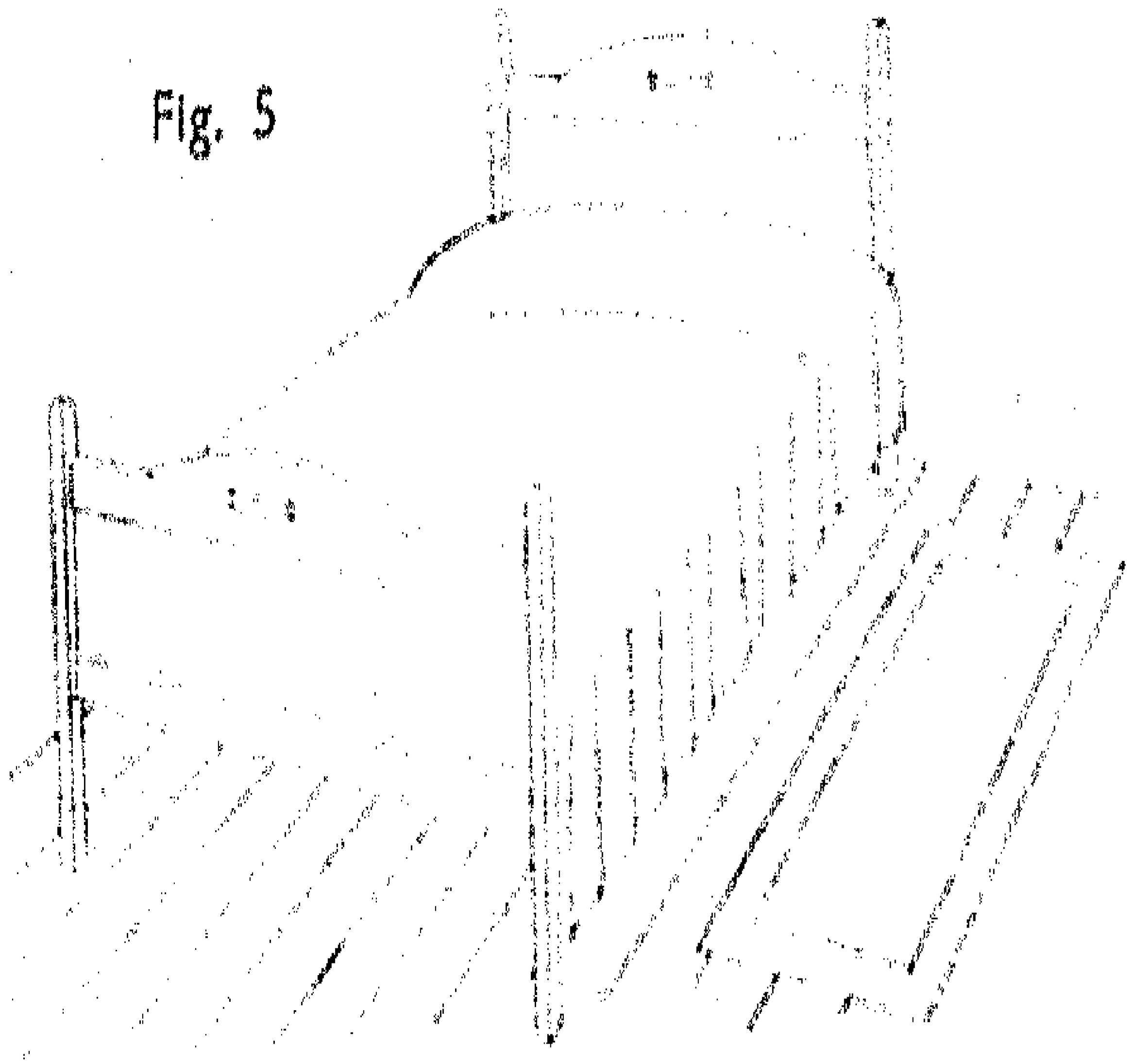
A door frame is necessary to hold the mirror. This may be arranged as shown



WARDROBE
WORKING DRAWING No 15

in detail in Fig. 3. The two side pieces or stiles are 2 in. wide on the outer face and the back is recessed in two steps each ½ in. wide. Assuming the mirror to be ¼ in. thick, the first step or recess is cut to suit and the next step behind this is cut another ¼ in. back to take the ¼-in. thick plywood backing. The shaped top rail and the bottom one are recessed in a similar manner and small dowel pins may be used at the ends as a means of fixing the side members. Extra battens fixed across the back over the panel and into the uprights will give additional support.

Fig. 5



To give the structure a finished appearance a piece of oak 4 ft. 10 in. long by 3 in. wide and ¾ in. thick should be shaped and fixed along the front edge at the top.

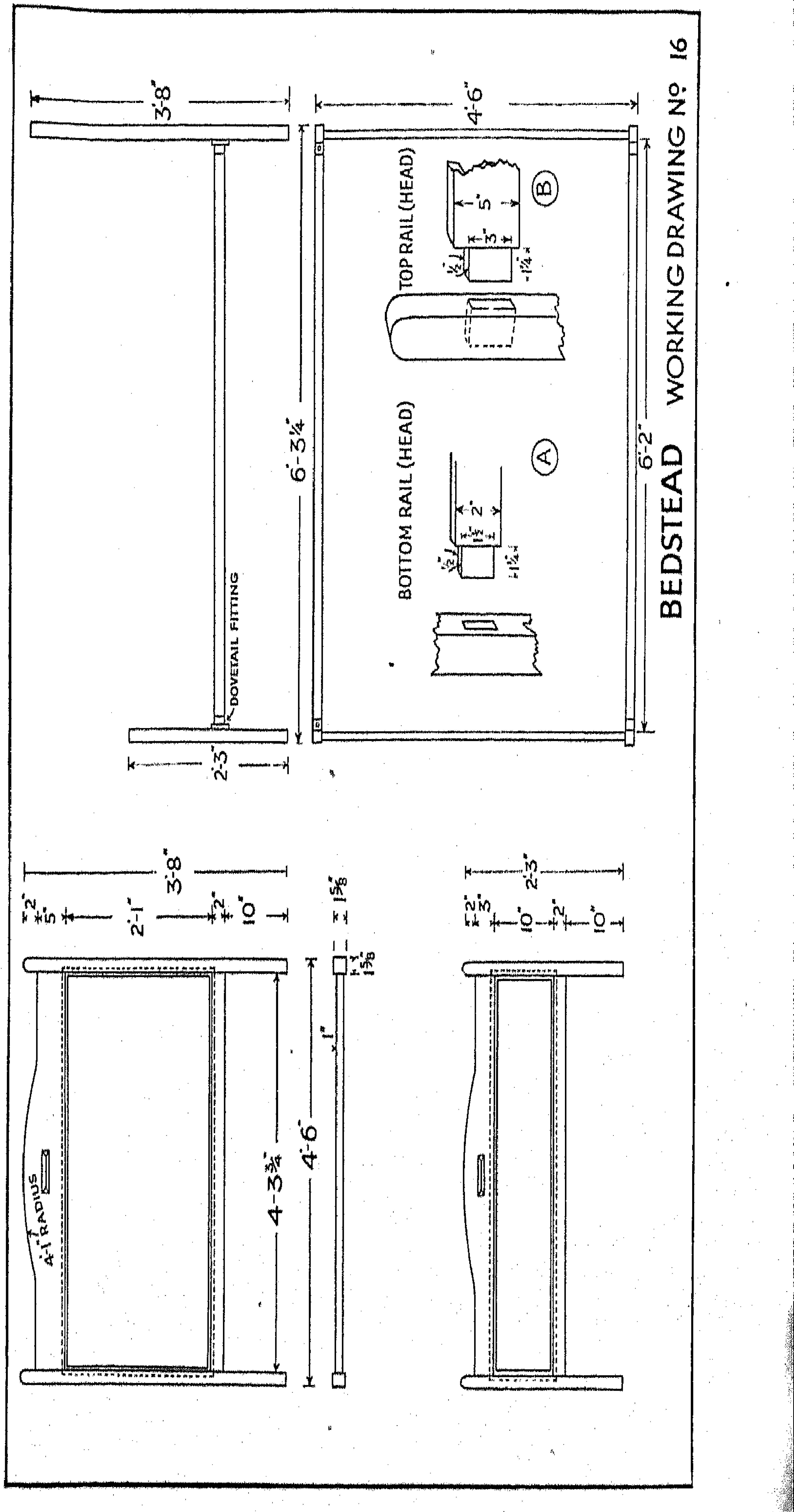
The Bedstead illustrated in Fig. 5 is of modern design and can be easily constructed with a few ordinary tools to be found in most home carpenters' kits.

As will be seen by referring to the working details (illustrated in Working Drawing No. 16), the head part of the bedstead consists of two posts of 1⅝ in. square section, into which the top and bottom rails are tenoned and glued, while the intervening space is filled with an oak-faced plywood panel ⅜-in. thick. The foot piece is constructed on practically similar lines, the main difference being that its height is lower.

The head and foot members are kept rigidly in position by means of longitudinal irons which fit into cast-iron dovetail fittings screwed to the back faces of the parts, as shown. These fittings can be obtained ready for fitting and are quite inexpensive. This method of support necessitates the use of a box mattress, which is placed over the supporting bars. Special wire mesh mattresses, complete with irons and dovetail fittings, can be used if desired. These mattresses are fitted with two screws which, when turned by a key, allow the tension of the springs to be adjusted.

Below is a cutting list of materials (oak):

Item	No.	ft.	in.	ft.	in.	in.
Head posts	2	3	8 ×		1⅝ ×	1⅝
Foot posts	2	2	3 ×		1⅝ ×	1⅝
Head top rail	1	4	6¼ ×		7 ×	1
Head bottom rail	1	4	6¼ ×		2 ×	1
Head panel	1	4	4½ ×	2	1¾ ×	⅜ plywood
Foot top rail	1	4	4½ ×		5 ×	1
Foot bottom rail	1	4	6¼ ×		2 ×	1
Foot panel	1	4	4½ ×		10¾ ×	⅜ plywood
Quarter round Moulding	50 ft.		½			



To this list must be added one pair of bedstead bars and four dovetail fittings for same, four castors, screws, glue, etc. The tools needed include a tenon-saw padsaw, jack plane, grooving plane, chisel and mallet, square, rule and glue-pot.

Start by cutting the posts to the sizes in the drawings. These are shown rounded at the tops and square at the bottoms. If desired, the portions of the posts below the bottom rails can be made a trifle tapered, but the ends should not be reduced to a smaller section than 1⅛ in. square, otherwise strength will be sacrificed.

Now cut and plane up a nice piece of oak 4 ft. 5¾ in. long by 7 in. wide and 1 in. thick for the top rail of the head of the bedstead, and a similar piece 5 in. wide for the top foot rail.

Mark out the positions for the tenons, taking all measurements from the lower edge, and scribe the top curve on the head rail to the radius shown in the drawing. If desired, the whole of the top edge can be one continuous curve, or even left straight, but if the latter be chosen, the overall width should not exceed 5 in.

Roughly saw out the surplus wood round the curve and finish it off neatly with a keen spokeshave, not forgetting to work it in the same direction as the grain. When finished, the curved portion can be laid on the foot rail and the curve traced on the latter, taking care to keep the ends flush with each other. Then cut out the curve as before.

Next prepare the two bottom rails. These are both the same size, namely, 4 ft. 5¾ in. long (allowing for the tenons) by 2 in. wide and 1 in. thick. Cut the tenons neatly with a fine tenon-saw to the dimensions shown at A in the detailed drawing of this part, and then proceed with the tenons in the top rails in accordance with the drawing shown at B. Mark the positions of the mortices in the posts from the tenons, and then cut them accurately to a depth of 1¼ in. after having removed as much surplus wood as possible with a brace and ⅜-in. diameter bit, taking every precaution to keep the bit square whilst so doing.

Cut the groove ⅜ in. wide and ⅜ in. deep in the centre of the inner side face of each post and also in the upper face of the lower cross-piece and the lower face in the upper rail.

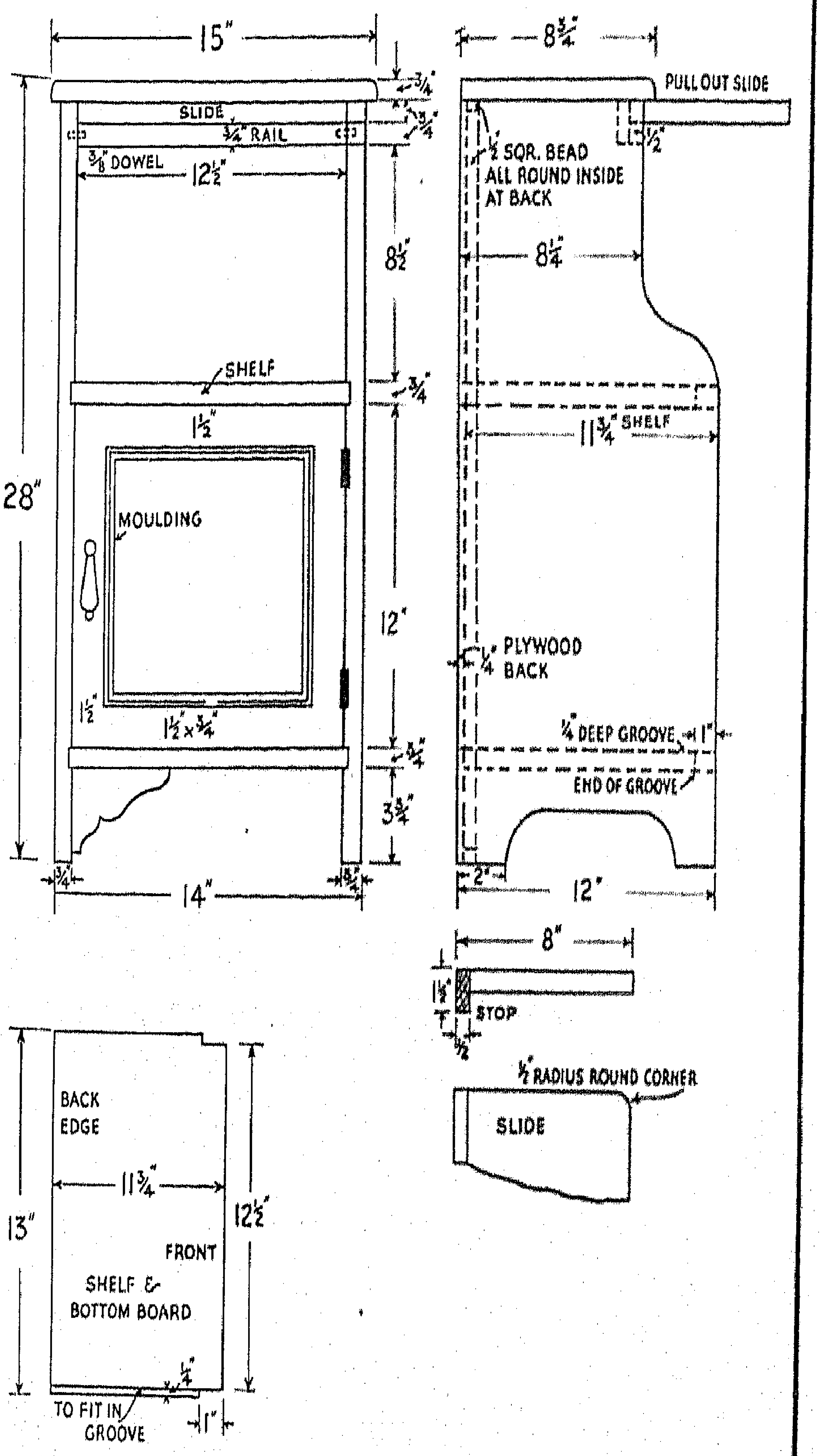
Having cut the panels accurately to size, and cut the small ornamental pieces for the rails, the assembly can be put in hand. Use very hot glue at the joints, the edges of the panels and the ornaments, then cramp up the members and leave them to dry. Fasten the ¼-in. round beading round both sides of the panels, using ⅝-in. fine panel pins driven in at a slight angle.

Give the whole of the woodwork a good smooth down with fine glass-paper, followed by a coat of glue size and stain to the desired shade to tone with other furniture in the room. The two members can then be varnished with a good quality oil varnish—not spirit varnish, as this has a somewhat brittle surface; therefore more likely to show scratches. If a duller finish is required, a good quality wax-polish will give the desired results.

The final steps consist in fitting the castors and screwing on the dovetail brackets for supporting the side rails.

The Bedside Cupboard illustrated in Fig. 6 and shown in Working Drawing No. 17 provides cupboard space of about 12 in. by 12 in. by 11 in. deep, in which a shelf may be fitted if desired. The top of the cupboard forms a shelf to hold a few books, and a pull-out slide for the morning cup of tea is a convenience if the top is occupied by a reading lamp.

Two sides, 27¼ in. long by 12 in. wide by ¾ in. thick, are reduced to 8¼ in. at the



BEDSIDE CUPBOARD
WORKING DRAWING No. 17

top end and shaped as shown. On the inner faces mark off the positions of the two dowels in the slide rail, and also the two grooves for the book-shelf and cupboard bottom. If the grooves are not to show on the front, they must be stopped at about 1 in. from the front edge, and the sides of the shelf and bottom board cut to suit. When the extra cutting is not thought desirable, the grooves may be taken right across, but the joint will show on the front, as in the front view of the cupboard. In any case the shelf and bottom board should be prepared first, and the grooves in the side pieces cut wide enough to allow the parts to be fitted without being too loose. These two boards extend to within ¼ in. of the back edge of the cupboard, leaving room for the plywood back.

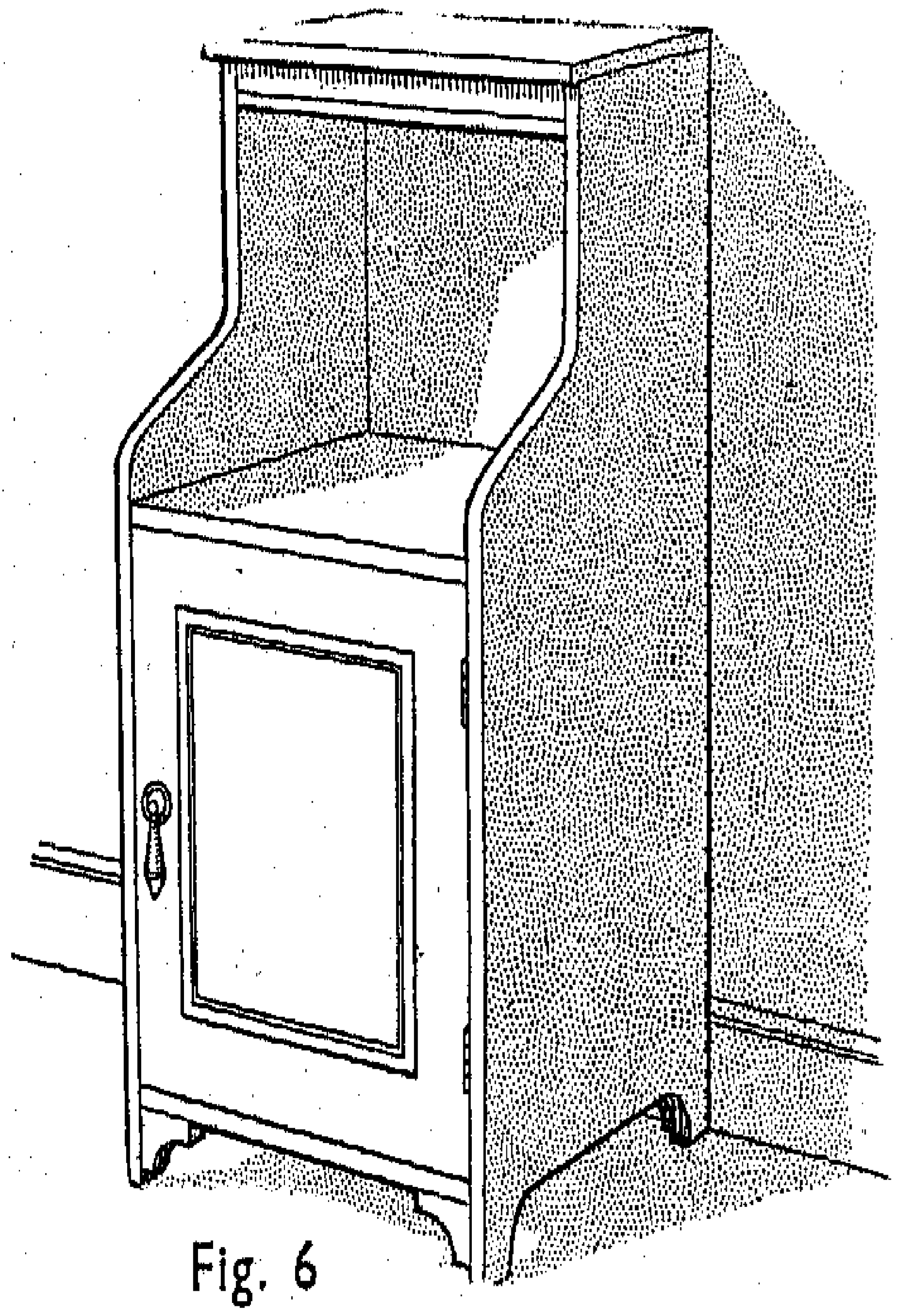


Fig. 6

The front rail under the slide is ¾ in. by ½ in. by 12½ in. long, fitted with a ⅜-in. dowel pin at each end, which does not show on the outside.

The top is 15 in. by 8¾ in. by ¾ in. thick, with all edges rounded off except the back one, which is flush with the back of the cupboard. The other edges overlap ½ in. all round.

Material ¾ in. thick is also used for the slide, which is made 12½ in. by 7½ in. with rounded corners at the front. This piece should now be fitted to the opening between the cupboard top and the rail by easing the edges and under surface until it will slide easily without being too loose, otherwise it will drop at the front when pulled out. A recess should be cut on the under side to the front to provide a grip for the fingers. The stop piece, ½ in. thick by 1½ in. wide, may now be screwed to the back edge, and cut slightly less in length so that it will not hinder the movement.

When the cupboard is assembled the slide is put through from the back.

The door frame is made up of 1½-in. wide by ¾-in. thick stuff, grooved for a $\frac{3}{16}$-in. thick plywood panel. The joints may be either the usual mortice-and-tenon or dowelled butt-joints. Thinner wood may be used for the frame, if desired, in which case the plywood must be large enough to cover the whole of the back. This method of construction saves cutting grooves. A suitable moulding is added round the frame as indicated, and a drop-handle fitting with catch. This and the hinges may be fitted on the other sides to those shown, if desired. Two shaped brackets are fitted in front below the door, more for finish than strength, and are secured by means of screws through the top face of the bottom board.

A fillet ½ in. square is fixed all round inside the back edge, ¼ in. back. This with the edge of the shelf and bottom are required for fixing the plywood back, which is in one piece.

AN INVALID TABLE

LIGHTNESS, rigidity and simplicity of construction are the outstanding features of the invalid table shown in the accompanying illustration (Fig. 1), and the dimensioned drawings in Working Drawing No. 18.

Such a table can be easily constructed in a few hours by anyone familiar with a few ordinary woodworking tools. The outlay of only a few shillings for the materials shows an enormous saving over a ready-made article.

The table has been designed for use with a single 2 ft. 6 in. wide bedstead having a low foot end, and enables the table to be wheeled from this end up to the patient. The span between the legs is sufficient to allow at least 6 in. on either side for overlapping bedclothes.

The table-top consists of a plywood panel, $\frac{3}{16}$ in. thick, supported on a frame, the long members of which are 4 ft. long over all, and of 1¼-in.-square section yellow deal. These members are kept at their correct distance apart by means of two ¾-in.-diameter dowel rods—one at each end—which form convenient towel-rails, and ¾ in. by 1 in. battens housed near each end, as shown in the detailed drawing, A. Two cross-pieces of 2 in. by ⅝ in. deal further support the panel near the centre, as indicated by the dotted lines in the plan view.

The long top members and end cross-pieces are rebated ½ in. wide and $\frac{3}{16}$ in. deep to allow the top surface of the panel to lie flush with the frame, while the centre-supports are fixed flush with the bottom of the rebate for the same purpose.

Two rails, 2 in. wide by ⅝ in. thick, are morticed into each pair of legs, as shown in the end view, the tops of the legs being fixed to the top members by means of long screws. The legs are kept rigid by means of shaped plywood brackets ¼ in. thick, which are glued into recesses or grooves cut in the undersides of the longitudinal members and the tops of the side faces of the legs, as shown clearly in the detailed drawing B.

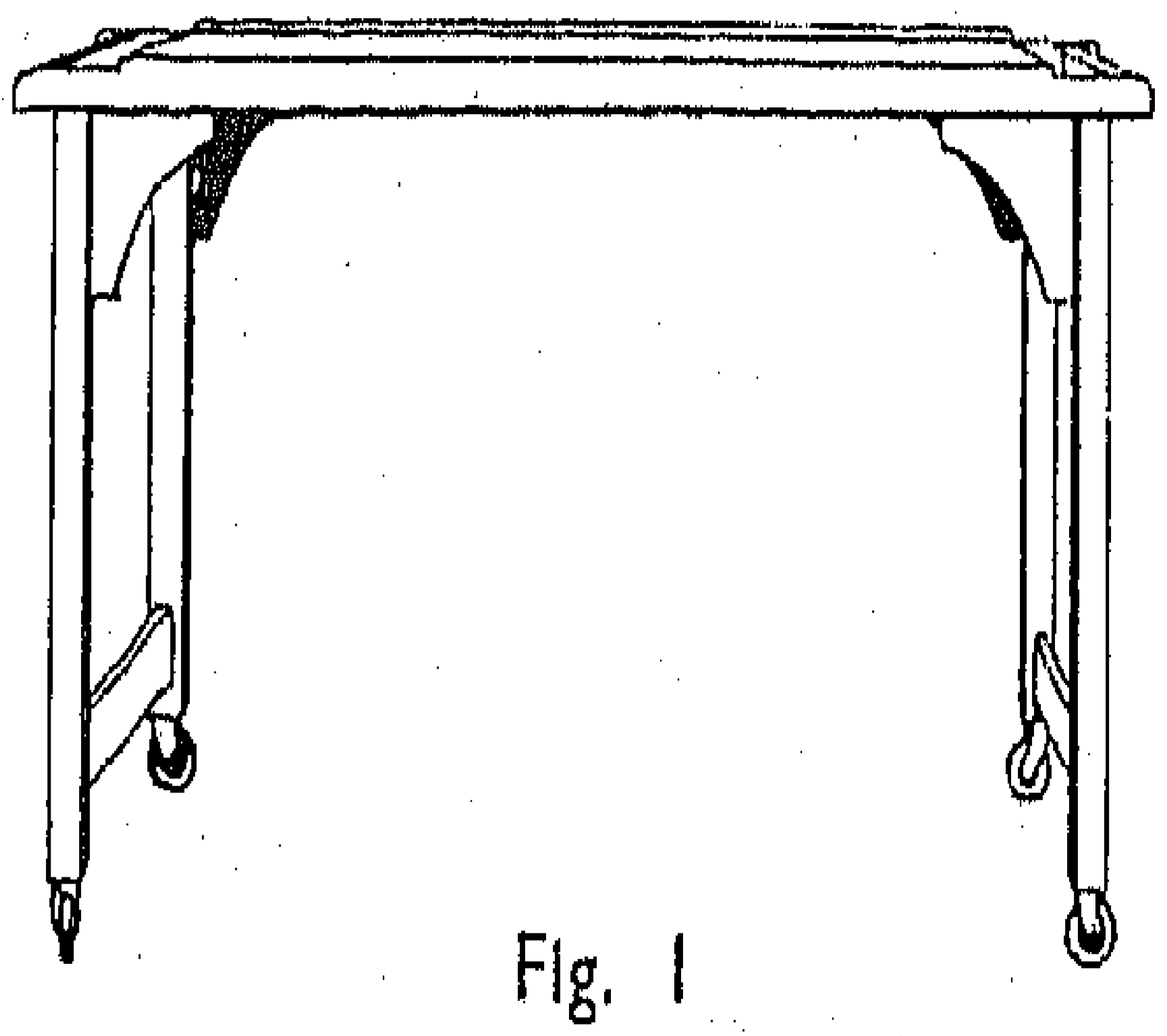


Fig. 1

Strips of ⅜-in. by ¼-in. beading having a rounded top are pinned along the outer edges of the table-top, as shown in the front elevation, to prevent articles from slipping off.

To Construct the Table, start with the legs. These are 1 ft. 11¾ in. long, of 1¼-in.-square section deal. Cut them to length and carefully plane to true section. Mark each leg for the mortices, which are 2 in. from the bottom and 1½ in. from the top, as shown. The size of the mortices is 2 in. long, ⅜ in. wide, and ¾ in. deep. Cut the grooves ¼ in. wide and ¼ in. deep to a length of 6 in. at the top of the legs to take the plywood brackets, and then glue and pin the rails to the legs. Cramp them up tightly and leave to dry.

Next, construct the top frame. Mark and bore the holes for the dowel rods in the centre of the inside faces. The centres for these are ⅞ in. from the ends, and the holes should be bored to a depth of ½ in.

Mark out the positions for the ¾-in.-wide cross-pieces, and cut recesses ¾ in. wide, 1 in. long, and ½ in. deep to take the ends. The top faces of these members should flush with the top faces of the long ones. Now mark the positions of the two middle cross members, which are merely cut squarely to length and fastened by means of screws driven through the sides of the long members. Mark and cut the grooves, ¼ in. wide and ¼ in. deep, on the underside of the longitudinal members to take the brackets, and cut a shallow recess $\frac{3}{16}$ in. deep, ½ in. wide, in the top and inner faces to allow the plywood panel to lie flush.

Prepare the two end cross-pieces and cut them to a finished length of 18 in. and then cut four pieces of ¼-in.-thick plywood, 6¼ in. square, mark the curve approximately to that shown, and saw them carefully with a fretsaw.

The next step is to cut carefully the plywood panel for the top to a size of 3 ft. 4½ in. by 18 in. Great care should be taken in preparing this, to see that it is perfectly square.

Drill the screw-holes through the sides of the long members to take No. 6 gauge countersunk-headed wood-screws for fixing the cross members, including the ends of the dowel rods. Countersink the tops of the holes sufficiently deep to enable the heads of the screws to lie well below the surface.

The parts may now be assembled. Get the glue-pot ready, and with plenty of hot glue join the parts together, starting with the end dowel rods, and secure these with 2½-in No. 6 screws, driven in tightly. Then glue the ends of the end cross-pieces, screw up, and then fix the middle cross bearers.

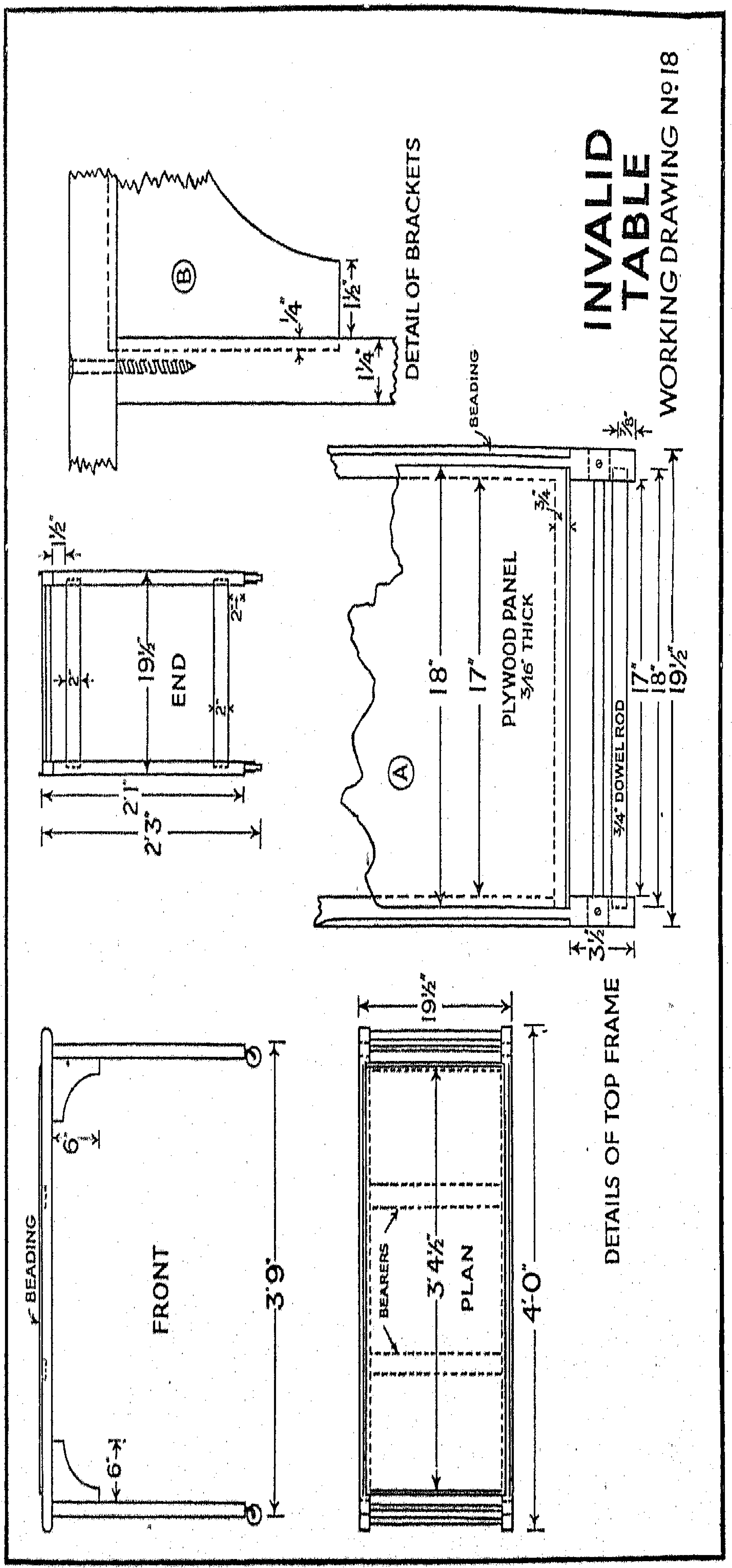
Brush some hot glue in the shallow recess for the edges of the panel, and also on the tops of the middle cross bearers. Place the panel in position and fix it down with ¾-in.-long panel pins spaced at distances of 6 in.

Having glued up and fixed the end frames, consisting of the legs and their cross members, fix them to the table-top. These are fixed by means of 2½-in. No. 8 screws, driven through the top frame into the tops of the legs. Brush some glue into the bracket recesses and slide the brackets into position, taking care to see that the legs are square with the top frame. When the glue has set perfectly hard, fasten the beading along the top long edges with glue and panel pins.

Stop up all the screw-holes with plastic wood and then smooth the whole of the table with fine glass-paper held in a wood block, and work it in the same direction as the grain. The constructional work is complete after having fixed the rubber-tyred castors.

To obtain a pleasing and durable finish, enamel is undoubtedly the best finishing medium. White, cream, or a light shade of blue is suggested; but the choice of colour must be left to individual taste.

Before applying the enamel, treat all knots in the wood with knotting, and then give it a good coat of glue size. When dry, give a priming coat of paint, followed by two further coats of flat undercoat paint, not forgetting to glass-paper the surface of each coat lightly before the next is applied.



AN INEXPENSIVE SIDEBOARD

THE sideboard pictured in the accompanying drawing has been designed to conform with modern conditions, namely, simplicity combined with utility. It has the straight lines so popular to-day but is, at the same time, as roomy as possible and suitable to any furnishing scheme.

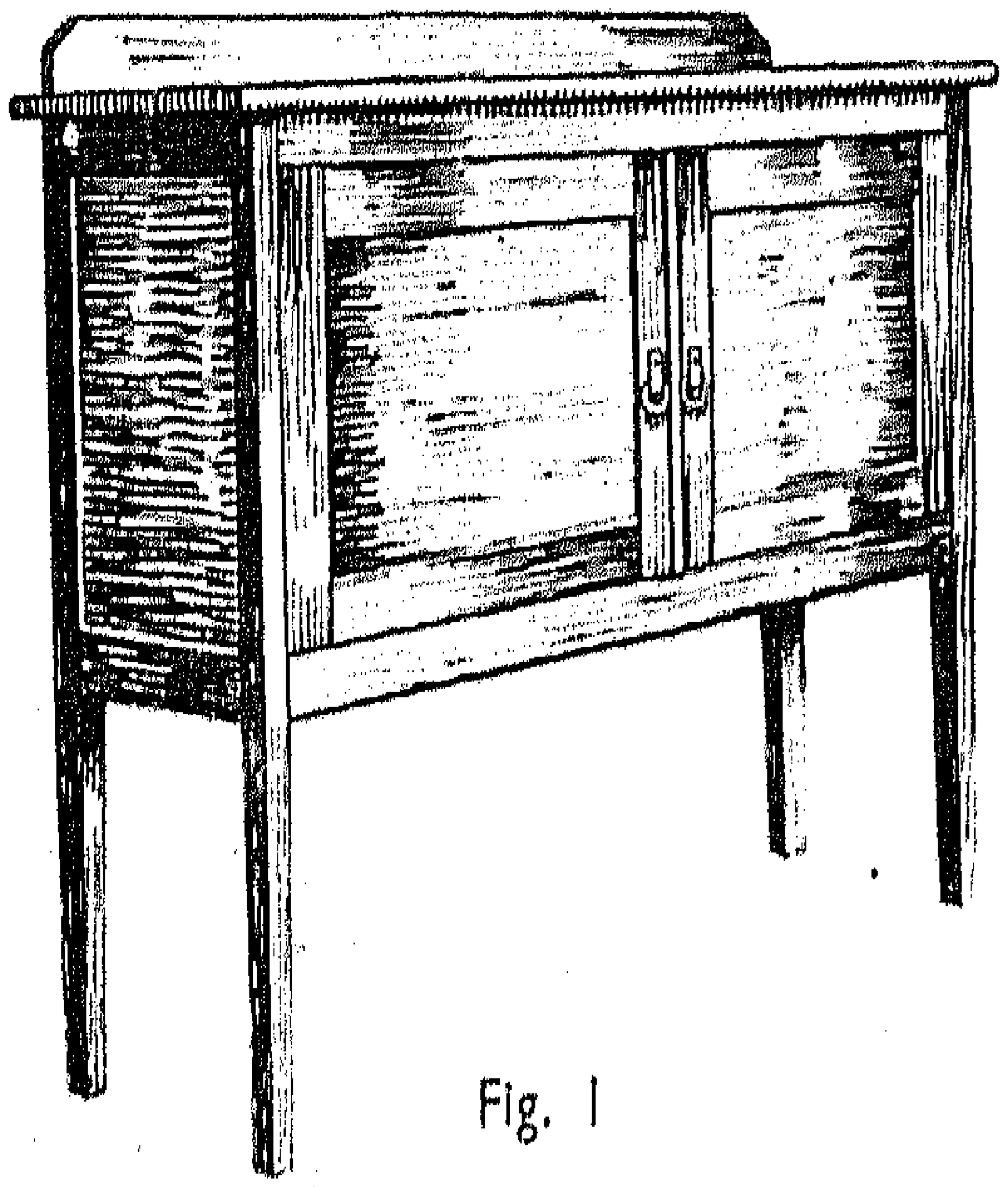


Fig. 1

In order to keep down the cost as much as possible, plywood forms the major portion of the material. Thus, the top is built up of ½-in.-thick yellow deal board, covered with a 3/16-in.-thick oak-faced plywood, the edges being hidden from view by means of half-round beading.

The interior of the carcass is divided into two compartments by means of a centre partition, which not only serves as a bearing for the top but also provides two roomy cupboards, capable of being fitted with shelves if desired.

Fully-dimensioned drawings appear in Working Drawing No. 19, and if they are followed carefully no difficulty should be experienced in construction.

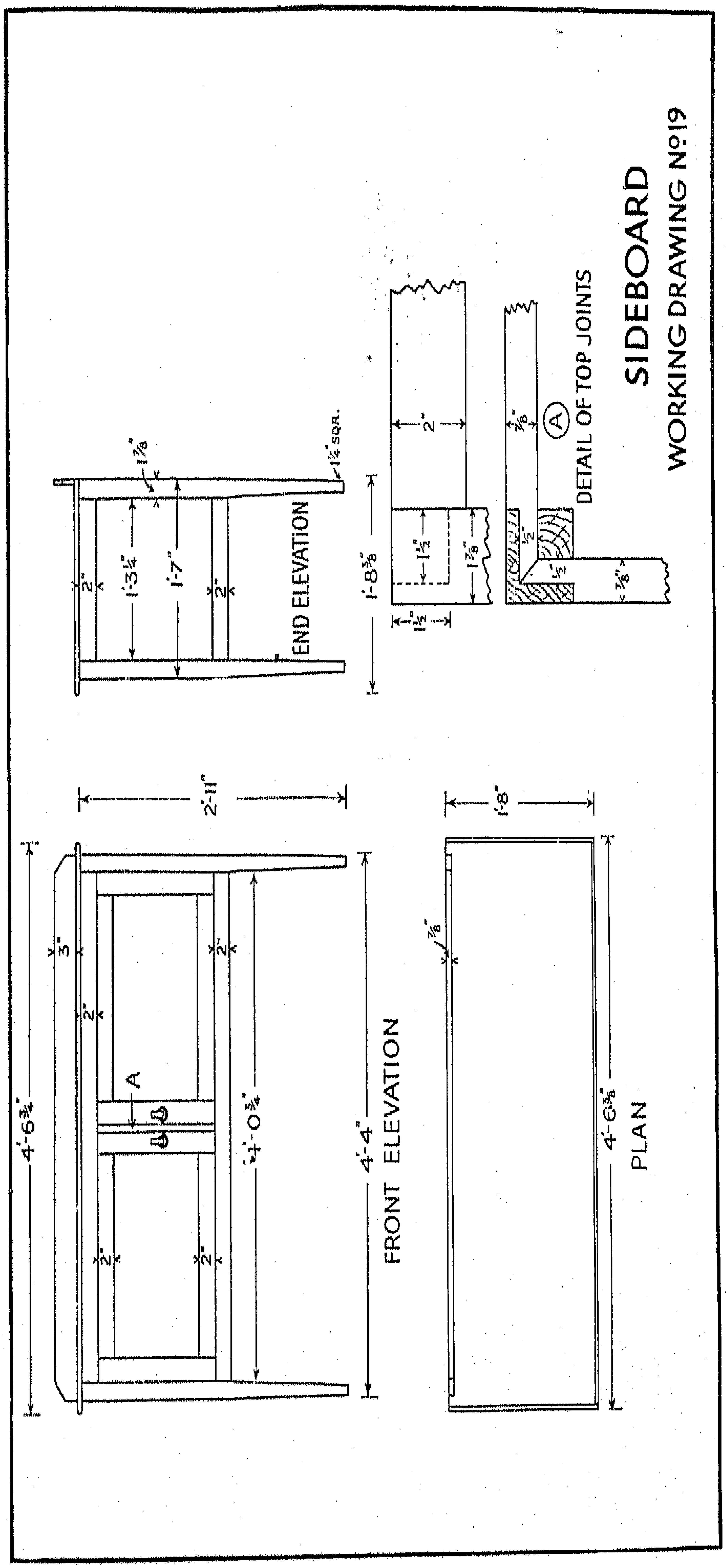
The materials, including such items as locks, hinges, screws, etc., can be purchased at most woodcraft shops, now to be found in nearly every little town.

The framework and legs are constructed from stock-sized material, ready planed and trued. The use of this not only considerably cuts down the cost by eliminating waste, but also dispenses with much tedious labour in the shape of sawing and planing.

Fifty shillings is the approximate cost of the material. The legs are formed of 1⅞-in. square section oak, 3 ft. long, costing 5s. per set of four. The rest of the main framework, door-frames, and the back board at the top are made from ⅞-in. by 2-in. section oak stripwood, costing 4d. per foot run. About 16 sq. ft. of figured oak-veneered plywood will be required for the top, sides, and door panels; this is listed at 9d. per sq. ft.

Ordinary birch-faced plywood of good quality will suffice for the back and the bottom of the cupboard, as they are hidden from view. These items involve the use of about 14 sq. ft., which is priced at 4½d. per sq. ft. Three 7-in. by ⅞-in. prepared (¾-in. thick, finished) deal boards and the shelves will cost about 5s., and to this must be added 5s. for stripwood, beading, fittings, etc.

Having obtained the material outlined above, start by marking out and cutting the tenons of the front and side top rails as shown in detail at A in Working Drawing No. 19. The tenons are 1½ in. long by ½ in. thick, and are cut 1½ in. wide to form a ½-in. shoulder on the underside when fitted to the legs. The ends of the tenons are mitred, as shown in detail, to ensure plenty of surface for gluing.



The next procedure is to cut the bottom rails to exact length, square the ends and bore them to take 2 ⅜-in.-diameter dowel pins, which are afterwards glued into corresponding holes bored into the sides of the legs.

Preparing the Legs.—Square the ends and cut them to an overall size of 2 ft. 11 in. This done, mark the tops for the mortices from the tenons already made in the top rails, and then carefully saw down on the inside of the marked lines to a depth of 1½ in., removing the waste with a sharp chisel. Mark the positions for the bottom rails and the dowel pins on the side faces of the legs and bore the holes with a sharp ⅜-in.-diameter centre-bit to a depth of ¾ in.

As the legs taper from full section at the lower edge of the bottom rails to 1¼ in. section at the feet, they should be carefully marked at this position and the ends, and carefully planed to size.

The next operation consists of assembling the frame and securing the joints with hot glue. When the glue is perfectly dry, fix a back and a front vertical piece to support the partition panel. The front one is indicated at A in the front elevation. These are fastened with screws driven through the top and bottom rails at the back and front. Fix a fillet of ¾-in.-square deal to the inner faces of the bottom rails to form a bearing for the bottom of the cupboard. The tops of the fillets should be flush with the tops of the rails. The bearers are fixed to the rails by means of 1½ in. by No. 6 countersunk-headed screws, driven in from the inside.

Before fixing the long back and front fillets, however, a piece of 2 in. by ¾ in. planed batten should be cut and fixed between the long bottom rails at the centre to form a central support for the cupboard floor.

A number of suitable lengths of ⅜-in. by ¼-in. stripwood should now be cut and pinned to the inner side faces of the rails and legs to form supports or false rebates against which the plywood panels fit. The horizontal strips should be laid flat with the narrow edge flush with the inside edges of the rails, keeping the vertical pieces—which are, of course, fixed to the legs—in line with them. Panel pins, ¾ in. long, may be used with advantage for fastening the strips.

At this stage the plywood panel for the bottom of the floor should be cut accurately to shape, not forgetting to cut recesses at the four corners to clear the corners of the legs, and two recesses in the centre to clear the partition uprights. The floor is fixed with ¾-in. panel pins, spaced about 6 in. apart. Cut the partition panel and fix in between the two vertical uprights by means of a ¼-in. stripwood, pinned to the floor and the inside faces of the verticals.

The side and back panels can now be cut to fit their respective rebates. They are kept in position by means of thin, round-nosed beading ⅜ in. wide by $\frac{3}{16}$ in. thick, fastened down with fine panel pins ¾ in. long.

If shelves are desired they should now be fitted. They are supported by 1-in. by ¾-in. cross-pieces, screwed to the legs and the partition, and may be fixed so that the shelves come midway between the floor and the top, or any other convenient position. Two 7-in. by ⅝-in. boards should be used for each shelf, which may be either bradded or screwed down to the supports.

The Preparation of the Top Board.—The 7-in.-wide (6⅞ in. finished) deal boards should be fitted together, long edge to long edge, with glued and dowel joints, and further strengthened with a couple of ¾-in. by 2-in. planed battens screwed to the underside, and spaced about 14 in. from the ends. When the glue is dry, the ends can be marked and sawn off squarely to length and skimmed

over with a sharp plane. This operation should be followed by planing the long edges to true width, namely, 1 ft. 8 in.

The deal top is then fixed to the top of the carcass by means of 1¼-in. screws driven into the top rails, care being taken to countersink the heads well below the surface. Now cut the plywood overlay exactly to size and apply a good coat of very hot glue to the deal surface and the underside of the panel. Place the panel on top immediately, to prevent the glue chilling, and apply pressure all over to squeeze out as much glue as possible. Partially drive in a few panel pins here and there, place as many weights as possible on top and leave to dry.

When you are perfectly satisfied that the glue is quite set, remove the weights and pins, fix the edge-beading and the back board. The latter is simply held in place with dowels and glue.

The doors consist of simple panelled frames, the stiles and rails of which should be properly joined by means of accurately-fitted mortice-and-stopped-tenon joints, or, if preferred, well-made dowel joints. False rebates, as used for supporting the side panels, may be employed for securing the door panels, but the strips forming the rebate should be glued as well as pinned, and it is an advantage to apply a small quantity of glue to the edges of the plywood.

Brass butt hinges should be used for hanging the doors. One leaf of the hinge should be let into the edge of the stile and the other into the leg, to enable the doors to open and close properly.

A suitable ornamental lock of an oxidised finish should be fitted to each door, and a small door-stop consisting of a small strip of wood must be fixed vertically to the side face of the partition, opposite each opening stile.

The whole of the outside of the sideboard should be thoroughly smoothed down with fine glass-paper and given a good coat of glue size. Stain of a suitable shade to choice can then be carefully applied and, when dry, the whole can be polished with one of the many excellent proprietary polishing-waxes.

A KITCHEN CABINET

THIS useful piece of furniture for the kitchen may be made on quite simple lines by the average home carpenter having a certain amount of skill in the cutting and joining of timber.

The design shown in Working Drawing No. 20, presented with this volume, has eight compartments. On the left are two cupboards 2 ft. deep from back to front. These are fitted with full-depth shelves, three in the top cupboard (No. 1 in the drawing of the framework), and two in the bottom cupboard (No. 2). None of these need extend to the front unless required. Section 3 at the top consists of two small cupboards, side by side, suitable for small articles not in frequent or daily use, such as spare electric-light bulbs. An open front shelf is provided in section 4 and this may be fitted with glass bottles or other marked containers for tea, rice, etc. Section 5 is enclosed with a door to open downwards from the top edge, and when this is lowered the inner surface, fitted with an enamelled plate top for cookery work, exposes the two sections behind, used for housing a flour container and other materials required for cooking and pastry-making.

The bottom central section has four

drawers, each of different depth, and a cupboard on the right with only one shelf, for larger articles, such as bread bin, etc.

The last section, No. 8, is a full-length cupboard for brooms, mop, brushes, etc., and the inside of the door is used to accommodate an ironing-board.

The first stage of the construction is to make the frame, the six uprights of which are each 6 ft. 3 in. long, cut from 2-in. by 1½-in. yellow deal. The three side-rails are also 2 in. by 1½ in. thick, and set to the front and back uprights, 1 ft. 9 in. apart. Mortice-and-tenon joints will give a more robust construction, although dowelled joints are more simple to make, and quite satisfactory provided a suitable-sized bit is used so that the holes are not made too large.

All the frame members should be finished first, the dowels fixed into the rails and the uprights bored to receive them at the correct positions. The four uprights of the left-hand section may be assembled in stages, first the front pair with the three front rails, then the back pair with three rails. The rails at the sides, from back to front, are then added and the intermediate upright for the front of the centre section. The right-hand section of the frame is built up in the same manner, and the parts of the centre section added. The centre post and runners for the drawers should be fixed before the plywood sides are put in so that there is room to reach round. The fillets to support the bottom and various shelves are also fixed in each section while the framework is open, then the inner ply divisions between cupboards may be added, and lastly, the shelves. The outer panels of plywood are added when the majority of the work is finished, and the top is left until last.

In the two cupboards of sections 1 and 2 the shelves are ¾ in. thick, and supported on runners or rails of 1-in. by 1½-in. stuff fixed between the uprights. Each complete shelf is cut away at the corners to clear the uprights, so that the shelf extends right up to the plywood sides and back. When several full-depth shelves are fitted, many articles may be hidden if the compartment is crowded, so some of the shelves need not be made to fill the space right to the front, but the remaining sections of shelving may be stored away, for use later as required. Shelf No. 6 and the bottom have smaller runners.

Each back section is filled in with a panel of $\frac{3}{16}$-in. plywood, so that the outer surface is flush with the face of the uprights. Beading of ¾-in. by ½-in. section, for supporting the panels, is tacked to the uprights and rails by means of panel pins. The same section beading is used at the sides for the side panels of plywood, but the beading is set back to the edge of the rail. This leaves a space of $\frac{9}{16}$ in. on the outer face. The beading is fixed with its ¾-in. face to the side of the upright in each case so that there is ample surface for fixing the beading, and the plywood to the beading.

Sections 6 and 7 are divided by the centre bar and a plywood partition which is fixed more towards the catch side of the cupboard door to allow room for the side runners of the drawers. The front bars between each drawer are 1 in. thick by 1½ in. wide. The side runners are of the same thickness and notched into the back uprights. A detail of this is shown in the Working Drawing. The shelf of cupboard No. 7 is ¾ in. thick and fixed to 1-in. by 1½-in. runners, the same as the others. This shelf can be fixed, of course, at any desired height.

The Four Drawers.—Each is a different depth, but other dimensions are the same, as indicated in the detailed sketch. The shallow one at the top is lined with green baize and fitted with divisions for knives, forks, etc.

Sections 3, 4 and 5 are set back 9 in. from the front edge, and extra uprights are used between the back and front centre pairs, and fixed to the top or shelf, which is 1 in. thick. The lower compartment, No. 5, has a flap door 1 ft. 6 in. high by 2 ft. 6 in. wide, by 1 in. thick. At the back an enamelled plate is fitted, so that when this door is let down it makes a table for cookery purposes; the two compartments at the back contain the various materials and small appliances, such as rolling-pin, egg-beater, etc. A pair of strong butt hinges is required for this flap door, and a simple catch let into the outer surface of the wood so that no part projects. The top of this compartment is 1 in. thick, and also forms the shelf above. It is supported by 2-in. by 1½-in. rails fixed to the sides and back of the framework at that point. The two compartments at the top are enclosed by simple plywood doors.

A suitable moulding is fixed along the top edge, starting from the back, along the side, and following the framework round to the back of the right-hand side, the ends being cut with external and internal mitres as required.

The Door Frames.—All four are constructed in the same manner, dowels being used to join the members, which are made out of 2-in. by ¾-in. wood. To the back of each frame $\frac{3}{16}$-in. plywood is fixed by means of small brads. As the long door on the right may tend to twist, extra battens may be fitted at the back after the plywood has been fixed. From the outside the door looks the same as the pair on the left, except that it is not so wide.

Hardwood dowel rod ⅜ in. in diameter is obtainable, and cut to length as required. The holes for dowels are the same depth in both pieces to be joined, so the dowel is sunk into one piece the same length as the projecting part. Glue should be applied hot to the dowels and the holes before fitting together, and to prevent the wood from splitting when the glued dowels are forced in, each dowel piece should have a small groove cut along the side from one end to the other. This will allow the surplus glue to escape, otherwise it will fill the space intended for the dowel, and tends to split the wood.

Two butt hinges for each door should be fitted on the inside and let into the sides of the frame and the door so that only the centre part of the hinge round the pin shows on the front. This makes a neat and correct job. The appearance of many home-made cupboards is spoilt by putting the hinges on the outside. Four hinges should be used on the long door. Suitable catches and knobs may be obtained cheaply from any ironmonger.

The whole of the top is covered in with sheets of plywood, fixed before the moulding is added, so that the edges of the ply are covered by the moulding.

The design and construction shown may be adapted for a smaller cabinet by leaving out the right-hand long cupboard. Other alternatives are to build the centre sections only, that is, those marked 3, 4, 5, 6 and 7. This would be suitable for use in a recess. The two cupboards of the left-hand section, built as a separate unit, would make a very handy fitting for the scullery, and with an alteration to the shelves could be made to take brooms and brushes also.

SIMPLE KITCHEN FITMENTS

The various devices described here will be found illustrated in Working Drawing No. 21, presented with this volume.

The Folding Clothes-horse shown in Fig. 1 is made from any prepared wood, or rough timber of good quality planed to the sizes given and finished smooth with glass-paper, and may be left in this state or finished with white enamel for easy cleaning.

Three frames will be required, each consisting of two legs or uprights $1\frac{1}{2}$ in. by 1 in. in section and 4 ft. long, braced across with three rails each 1 in. by $\frac{5}{8}$ in. by 2 ft. 6 in. long over all. All six legs are cramped with the $1\frac{1}{2}$-in.-wide faces together, and the mortice holes marked across them at the given distances from the lower end for the lower pairs, and at 2 in. down from the top for the top rails. Each mortice is $\frac{1}{4}$ in. wide and central on the 1-in.-wide face of the leg, passing right through. The nine rails may be marked out in the same manner in sets of three and the tenons cut as shown.

The bottom ends of the legs should be squared to stand firm, and the top ends rounded off with a chisel and rasp, and made smooth. When the rails have been fitted, glue and screw them firmly in place. Next hinge the three frames together, using stout upholstery webbing for the hinges.

Commence by nailing one end to the outer face of leg A, just below the top rail. Turn the webbing over the joint face, and nail it to the inner face of leg B. Use galvanised tacks with flat heads. Now fix the second piece below the first, to the inner face of leg A, pass it over the joint face and fix to the outer face of leg B. With two or three groups of webbing at each joint edge the horse may be turned in any direction and be folded flat.

The Hinged Scullery Table shown at Fig. 2 will prove very convenient where space is limited, as it only projects 3 in. from the wall when not in use. In the small modern house, fitments that fold out of the way when not in use are a boon to the housewife.

First make up the wall frame out of 2-in. by 1-in. finished yellow deal. Cut two pieces 2 ft. 6 in. long, and two 1 ft. 10 in. long. At the ends of the latter pair cut the tenons $\frac{3}{4}$ in. wide as shown in the detail, and notch the ends of the horizontal members to correspond. Through the 1-in.-wide face of each horizontal member drill two holes for the screws for fixing the frame to the wall. These should just clear the size of screw used.

Cramp the two long pieces together and drill clearance holes through the 2-in.-wide faces for the pivot screws of the brackets. When the latter are folded in there should be enough space between the back edge of the bracket and the inside of the frame to allow the batten underneath the table-top to pass between when lowered.

Glue and screw the frame-joints firmly and use the finished frame for marking the position on the wall for the plugs, by passing a long bradawl point through the drilled holes when the frame is held against the wall. The height from floor to table-top is left to suit the convenience of the constructor. A pair of stout butt-hinges are fitted to the frame without hindering the movement of the brackets.

The brackets are made of 1-in. by $1\frac{1}{2}$-in. material with halved joints. The back edge of the vertical member may be rounded off if necessary for clearance, and the whole made an easy fit without being too loose in the frame. The fixing, by means of long wood-screws passing through the frame into the ends of the bracket, is best done with the bracket in the closed position. The ends, after having been marked through for holes in the frame, may be drilled for part of the depth with a smaller diameter drill to prevent splitting.

The top consists of two boards, each 9 in. wide, with 1-in. by $1\frac{1}{2}$-in. battens screwed to the underside. The hinged top is covered with a piece of linoleum tacked on, and the remainder of the woodwork may be painted.

Egg Stand.—A safe storage for eggs is provided by the stand illustrated in Fig. 3, and may be made in two or more sections as required. The top is 5 in. wide by $13\frac{3}{4}$ in. long, and has 12 holes, each $1\frac{1}{2}$ in. in diameter, bored at the centres shown. Supporting pieces are required at the ends only. Each support has a slot cut for lifting purposes, and if more than one stand is to be used, dowel pins are fitted in the lower edge to fit into holes drilled in the top face.

Airing-rack.—Fig. 4 gives details. Two ends of $\frac{7}{8}$-in.-thick wood are required, $3\frac{3}{4}$ in. wide by 20 in. long, 5 round rods each $\frac{7}{8}$ in. in diameter being used (obtainable in lengths of 8 ft.). The position of the ceiling joists should be found before any attempt is made to suspend the rack in position.

Plate-rack.—The material required for the plate-rack (Fig. 5) is three pieces of wood $\frac{3}{4}$ in. thick, 7 in. wide by 18 in. long for the top, bottom, and shelf. The last piece is cut $1\frac{1}{2}$ in. shorter to fit inside the frame. Two sides, also $\frac{3}{4}$ in. thick, are 7 in. wide by $24\frac{3}{4}$ in. long. At about $1\frac{1}{2}$ in. back from the front edge on each piece except the sides, mark a centre line and space out the positions for the $\frac{1}{2}$-in.-diameter dowel rods. The 12 rods may pass through the shelf and the top, but not right through the bottom. The finished rack may be secured to two metal brackets fixed to the wall with plugs.

The Food-safe (Fig. 6) is intended for use indoors in any cool, well-ventilated place. The back is covered in with ply or matchboarding.

For the safe, make up two frames 16 in. by 24 in. out of $1\frac{1}{4}$-in. by $\frac{3}{4}$-in. deal, fixing the top and bottom members into the verticals as indicated in the detail. The rails connecting the two frames to form the sides are also $1\frac{1}{4}$ in. by $\frac{3}{4}$ in., fitted with $\frac{3}{8}$-in.-diameter dowels at the ends for fixing into the frames. The centre rail on each side forms a ledge for the shelf-boards, which are removable for cleaning. Beading $\frac{3}{8}$ in. by $\frac{1}{2}$ in. is nailed all round inside the frame flush with the back face. To this the perforated metal is fixed and the edges are covered all round outside with a strip of wood, as shown. Both sides are treated in the same manner, and $\frac{1}{2}$-in.-thick bead is fixed round the door-opening to form a stop.

The bottom and top may be of matchboarding. The door frame is also of $1\frac{1}{4}$-in. by $\frac{3}{4}$-in. material and enclosed with similar sheet metal as the sides. When fitted on hinges the door should be an easy fit for opening.

The Draining-board (shown in the drawing at Fig. 7) is made to slip over the edge of the sink, so the piece under the front edge is fixed at an angle to give the top board a slope when in position. The gap between the back of this underpiece and the ends of the triangular pieces should be made to suit the thickness of the sink. Edging, $1\frac{1}{2}$ in. by $\frac{1}{2}$ in., is nailed along each side, and the top surface is grooved with a $\frac{3}{8}$-in. gouge to allow the water to drain away.

A PORTABLE GARAGE

The motor-house described in the following paragraphs and illustrated in Fig. 1 with details in Working Drawing No. 22, presented with this volume, has been designed for the owner-driver who, as a practical man, is usually familiar with the use of tools.

The structure consists of a wooden framework clad with asbestos sheets, roofed with asbestos-cement tiles.

Such a garage will conform to the requirements of most public authorities.

The size is 16 ft. long, 9 ft. wide, 7 ft. to eaves, and 8 ft. 9 in. to ridge. This size allows ample room for accommodating the popular small-sized car and leaves sufficient space at the end of the structure for a small bench.

When the necessary plans have been passed by the local authorities, the first thing to do is to mark out the site, remove the soil, and level the ground for the concrete floor. If possible, the floor should be arranged to have its top surface 4–6 in. above the ground level and not sunk below. This method allows the asbestos covering on the outside of the structure to overlap the sides of the concrete for a few inches and thus prevents any water finding its way, between the surface of the floor and the bottom plates, into the interior.

In constructing a building of this description it should be borne in mind that provided the structure is not fixed down permanently to the ground, it is classed as a temporary building and therefore a tenant's fixture which may be removed when desired. Thus, the building here described comes under that category, because it is merely fixed to the floor by means of bolts and nuts which can be easily unscrewed.

Having accurately marked out the site by means of four pegs driven into each corner at the correct distances apart, and removed the top layer of soil to a depth of 3 in., the excavation should be filled in with a layer of coarse clinker or with broken brick rubble and the whole either rammed down or rolled perfectly hard and level.

The next procedure is to enclose the floor space with thick boards set round the edges and level with the top surface of the concrete, which should not be less than 4 in. in thickness. In fixing the boards, make sure that their tops are perfectly level, as tested with a spirit-level, and drive in a number of stout pegs at distances of about 3 ft. apart, on the outside of the boards to prevent them bending outwards, when the wet concrete is poured in. The entrance end should slope down gradually for about a couple of feet to ground level to prevent the sharp edge of the concrete damaging the tyres.

The Concrete Floor consists of two layers. The bottom layer is 4 in. thick and is made of coarse stuff by mixing 1 part of Portland cement to 2 of clean sharp sand and 4 of aggregate, consisting of clean broken bricks, or shingle of about 1½ in. diameter, while the finishing layer consists of cement mortar in the proportion of 1 of sand to 1 of cement. Sufficient time must be allowed to enable the bottom layer to set hard before adding the finishing layer, it being protected, in the meantime, against extreme weather.

When preparing the floor, bed in the holding-down bolts, not forgetting to apply a liberal supply of grease to the threads above the level of the floor, to prevent rust. The bolts should be 6 in. long and ½ in. diameter and project 3 in. above the floor level, and a washer should be placed on the head before insertion. The positions for the bolts are 1½ in. from the edges, two being required for each side and two at the back. Great care must be taken to see that the bolts are perfectly upright, otherwise difficulty will be experienced when fitting the bottom plates of the framework.

A hole about 4 in. deep and 4 in. square should be left near the front edge of the floor, at the door end, to accommodate the iron dowels which are fitted to the bottoms of the door-posts, as shown in the front view, the holes being filled in with "grout" or liquid cement after the posts have been fixed in position.

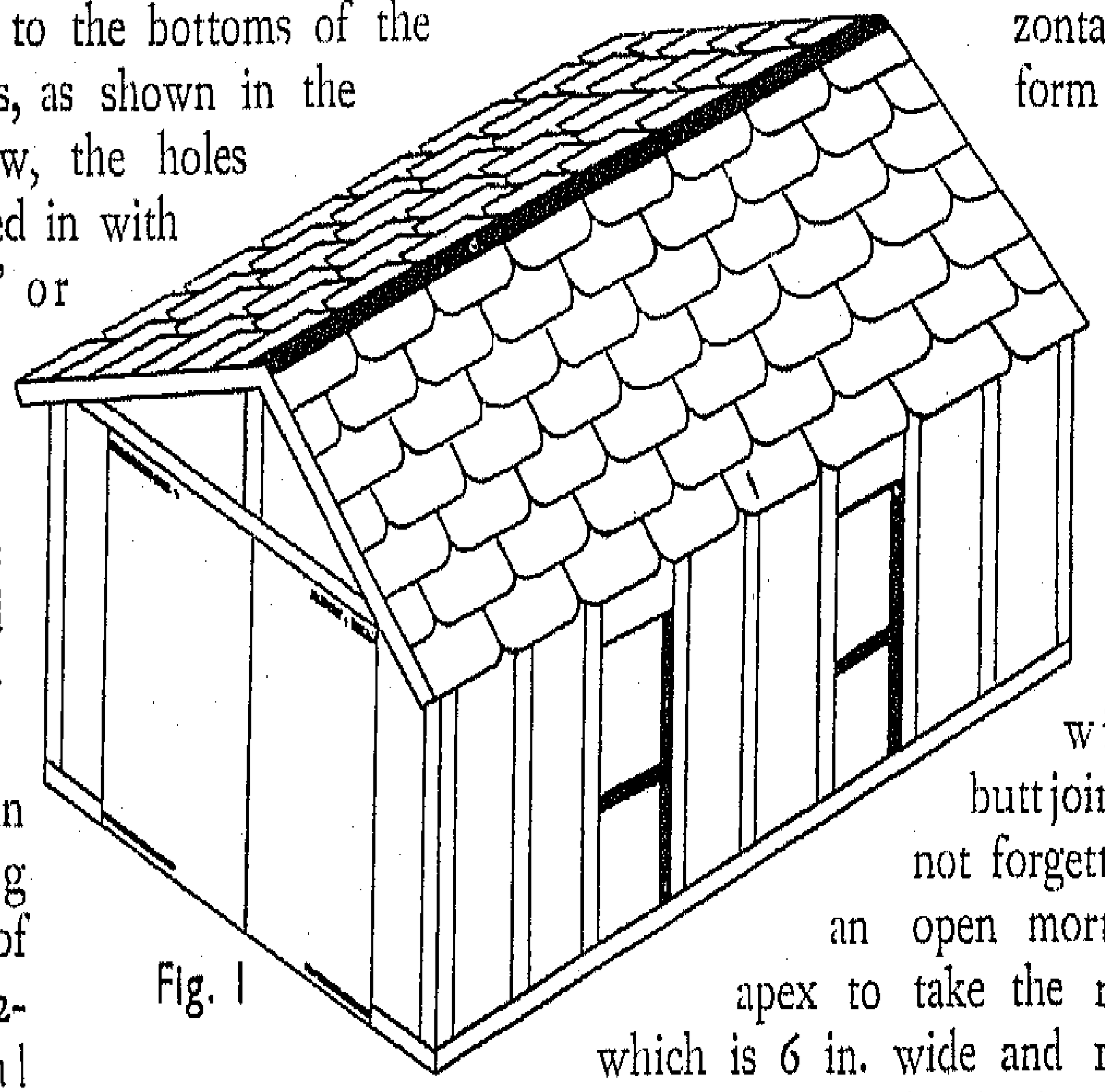


Fig. I

The main framing consists of 3-in. by 2-in. deal scantling, and all joints are made by butting and nailing members together.

Cut off 4 16-ft. lengths for the top and bottom side rails and 18 7-ft. lengths for the vertical members or "studs." Lay one of the 16-ft. lengths flat on the floor and mark the exact positions for the ends of the studs, which must be 24 in. apart, centre to centre. Then by means of a square transfer the markings to the other rails. Drill two holes with a brace fitted with a $\frac{3}{16}$-in.-diameter spoon bit through the rails, in the centre of each marked position, keeping them 1 in. from the long edge. These are for inserting 4-in. long wire nails which fasten the studs and prevent splitting.

Now fix the uprights to the rails by nailing them together. As this cannot be conveniently done in a vertical position, the best way is to place the rails, narrow edge downwards, on the concrete kneel on the uprights to keep them from shifting and drive in the nails.

Having fixed all the uprights, square up the frame and fix a 4-ft. long batten diagonally across each corner to keep it square. Mark, cut and fix the wind braces between the first, second and third studs at each end, as shown in the elevation, and then fit the short horizontal pieces to form the window frames.

Prepare the end or back section in the same manner, and cut and fix the end gables with nailed butt joints as shown, not forgetting to make an open mortice in the apex to take the ridge board, which is 6 in. wide and 1¼ in. thick. When cutting the back uprights, do not overlook the fact that they are 2 in. longer than the ones in the side members. The extra 2 in. on the height of these allows the ends of the roof rafters to rest on the top rails of the sides.

Having so far completed the framing, drill the holes in the bottom rails to take the holding-down bolts. These should be clearing holes bored with a ¾-in.-diameter bit to allow for slight adjustment. Two holes, $\frac{5}{16}$ in. diameter, should also be drilled in each side end upright, about 18 in. from the top and bottom, to take the fixing-screws.

The three sections may now be erected with the assistance of a helper. Lay one side flat on the floor, with the bolt holes opposite the bolts in the concrete, and lift up into position. In order to hold the side up whilst getting ready for erecting the opposite side, two lengths of 3-in. by 2-in. stuff about 10 ft. long should be used as supports. One end of each is nailed temporarily to the top rail near the ends and the other ends of the supports rest against heavy weights placed on the floor.

Follow the same procedure with the other side and then the back, and fasten them together with stout screws or coach bolts 4 in. long, driven in from the inside.

Place a washer on each holding-down bolt and screw on the nuts.

Next, prepare the front as shown in the front view in the Working Drawing. Cut two 7-ft. lengths of 6-in. by 3-in. timber for the door-posts, and drill a ¾-in. diameter hole to a depth of 4 in. in the centre of the bottom of both pieces. These holes are for taking the dowel pins, which enter the holes already prepared in the concrete floor. The "pins" consist of pieces of ¾-in.-diameter heavy-gauge electrical conduit, or gas barrel of the same diameter. The tube is driven into the holes in the bottoms of the posts, allowing 4 in. to project.

Fix the door-posts to the end vertical members of the side sections by driving in three 6-in. stout screws from the outside. Cut and nail on the lintel or cross-piece above the door and then fix the gable as before. Fill in the holes at the feet of the door-posts with neat liquid cement and allow it to set.

Next fix a 17-ft. length of 6-in. by 1¼-in. deal between the morticed members of the gables, to form the ridge. The ends should project 6 in. at each end.

Now cut 14 roof rafters, each 5 ft. 2 in. long, and carefully mark and trim the ends to an angle to correspond with the slope of the roof. This done, fix them down to the top plates and the ridge board, using 6-in. wire nails for the former and 3-in. ones for the latter.

When the rafters have been securely fixed, roof trusses consisting of 3-in. wide by ¾-in. thick battens should be nailed across each rafter in the manner shown in the diagram. The purpose of these members is to brace the sides of the roof and tie the walls to prevent them spreading out.

The whole of the roof should now be covered with ⅝-in. thick roofing boards.

A facia board of 3-in. wide by ¾-in. planed batten should be fixed to cover the ends of the roof boards.

Now fix the external sheets of asbestos-cement. Four 8-ft. by 4-ft. sheets will be required for each side. Two similar sheets will partially cover the back, another is necessary for the doors, while an additional strip 8 ft. long by 1 ft. wide will be required to cover the centre space at the back. Two pieces 4 ft. 3 in. long by 3 ft. 9 in. wide can be cut diagonally to fit the front and end gables, while a couple of strips 7 ft. long by 9 in. wide for covering the door-posts completes the list of sheeting.

The asbestos-cement sheets should not be less than ¼ in. thick and they should be cut to allow a 3-in. overlap at the bottom of the floor plates all round. As the sheets covering the sides butt up against the underside of the roof boards, recesses will have to be cut in the tops of them to clear the ends of the roof rafters.

Having cut the sheets to length, offer up the first one at the door end, mark the positions of the rafters at the top edge and cut the recesses, bearing in mind that the long edges should come in the centre of the studs. Fix the sheets to the studs, including the intermediate ones, by means of 1¼-in. galvanised flat-headed nails spaced at intervals of 6 in. and not less than ½ in. from the edges, leaving a small gap $\frac{1}{16}$ in. wide

between each joint. Proceed in the same manner until both sides are complete.

The lengths of the end sheets are 7 ft. 5 in., which allows 3 in. at the bottom as before and 1 in. bearing on the top cross-rail. Fix the two end pieces first and then cover the gap in the centre with the 1-ft. wide strip.

Do not cut out the window apertures before fixing the sheets, as these may be easily cut out with the aid of a padsaw after the sheeting is in position.

The joints between the sheets are covered with planed and slightly chamfer-edged battens, 2 in. wide by ½ in. thick, and for the sake of appearance a covering strip can be fixed over each intermediate stud. Before fixing the battens, give them a good coat of creosote, if this is to be the finishing medium, or, if paint is to be used, treat any knots in the battens with "patent" knotting and then give the strips a good priming.

Covering the Roof.—The "gauge," or the distance between one horizontal edge of one course to another, is, for centre nailing, half the length of the slate minus the amount of lap. This, with a standard slate, namely, 15¾ in. by 15¾ in., allowing 2¾ in. lap, which is the usual allowance for this type of roof, will be $\frac{15\frac{3}{4}\text{ in.} - 2\frac{3}{4}\text{ in.}}{2} =$ 6½ in., or, in other words, this is the amount of each course that will be seen. From this it follows that each slate covers an area of 6½ in. by 15¾ in., or 102⅜ sq. in., and the number of slates to cover 100 sq. ft. will be

$$\frac{100 \times 144}{102\frac{3}{8}} = 140 \text{ approximately.}$$

As the area of the garage roof is 170 sq. ft. or, say, 175 sq. ft., the minimum number of slates required to cover the area will be $1\frac{3}{4} \times 140 = 245$. To this number must be added a sufficient number of slates to cover four extra courses—one at the ridge and one at the eaves on both sides of the roof.

The slates are laid upwards from the eaves and a double course, as mentioned above, should be fixed at this position, while the bottom of the slates should overlap the edges of the boards by 2 in. The overall length of the eaves slates, or lower course, will be gauge plus lap = 6½ in. + 2¾ in. = 9¼ in. This course will be entirely covered by the next. The bottom course slates may be easily cut to size by scoring with a chisel and breaking over the straight edge of a piece of batten. Another double course will be needed at the ridge, which will be partly covered by the ridge.

The chief points to observe in fixing the slates are to keep each course perfectly parallel and the vertical joints of alternate courses strictly in line.

The best kind of nails to use for fixing the slates is the galvanised-wire type, 1½ in. long.

Having completed the slating, a suitable roof ridge should be fixed. This article, made of asbestos-cement, can be had in various forms, and can be obtained from most builders' merchants. A triangular-shaped ridge having a slope of 25° is recommended, the standard size of which is 24 in. long plus 4 in. overlap, and 11 in. wide. The pieces are fixed by means of screws driven into the top of the ridge board.

The Doors.—All that remains to be done now is to make and hang the doors and windows.

A little care is necessary in making the doors, details of which appear in the Working Drawing, otherwise it will be found in a very short time that they will drop and bind on the ground. The distance between the door-posts is 7 ft. 6 in. and the height from the floor to the cross-rail is 7 ft. Therefore two doors, each 3 ft. 9 in. wide and 7 ft. high, will be required.

Cut off and plane up 4 stiles or uprights 7 ft. long and 6 rails 3 ft. 9 in. in length of 3-in. by 2-in. stuff, and make the doors with proper mortice-and-tenon joints, and cut in the braces after framing up. Plane off ¼ in. from the bottoms to allow for ground clearance, cover the frames with a sheet of asbestos nailed from the outside, and cut the edges flush with the framing.

Obtain two pairs of medium weight wrought iron reversible gate hinges and fasten them to the top and bottom rails by driving the fixing-screws through the asbestos covering. Offer the doors up into position and after allowing for ground clearance, mark the positions for the hinge cups on the side panels. Fix the bottom cups and drop the hinges into position and then finish by fixing the top cups. The object of allowing the stiles to project beyond the top and bottom rails will now become apparent —there would not be sufficient room for the hinge cups otherwise.

Nail a ¾-in. by ¾-in. fillet on the under face of the top cross-piece to act as a door-stop, and screw a 2-in. by ¾-in. planed batten to the long opening edge of the right-hand door. This strip should project 1 in. beyond the edge to overlap the other door when closed, and prevent the entry of rain water. Fix a shooting bolt at the top and a similar one at the bottom of the opening stile of the left-hand door, chip out the concrete to allow the lower bolt to shoot, and drill a hole in the cross-piece for the other. Finish the door by fixing a 9-in. hasp and a padlock.

The Windows should be made to open to give adequate ventilation when working within. The apertures in the framework, which are 1 ft. 10 in. wide, should be provided with sills 2 ft. 4 in. long by 5 in. wide and 2 in. thick. Each sill is cut out to fit between the uprights and allows a projection of 3 in. on both sides of the window frame. The tops of the sills should slope off towards the front and be channelled on the underside about ⅛ in. or so from the front bottom edge to prevent water penetrating the joint.

Line the sides and tops of the window apertures with 3½-in. by ½-in. planed stuff and then make and fit the sashes. These should be made of prepared best yellow deal, 2 in. wide by 1¼ in. thick, and the rails and stiles should be fixed together with mortice-and-tenon joints. To save the labour of planing the rebates for holding the glass, false rebates consisting of ½-in. by ⅜-in. strips can be bradded to the inside faces of the sashes, keeping the back edge of the strips flush with the backs of the frames. The sashes should then be knotted and given a good coat of priming paint. When dry the sashes can be glazed with 21-oz. glass. They should then be tested and eased if necessary, and then hung from the tops by means of butt hinges.

METAL WORK

METALS AND THEIR USES

NEARLY everybody knows that a metal is an opaque substance which cannot be dissolved in water but is capable of being melted by the application of heat. An alloy is composed of two or more metals mixed together when they are in their molten state. A metal is said to be tenacious if it is tough, and ductile if it can be hammered to shape or drawn out easily without injury.

Cast Iron or **Pig Iron**, as it is sometimes called, because the iron is cast into moulds called "pigs," is impure iron, the chief impurities being such substances as sulphur and phosphorus. These elements in iron give different properties. Cast iron has an appreciable amount of carbon in its composition—over 1½ per cent.—and is crystalline in texture. It is brittle and not at all ductile, which means that it cannot be hammered without injury. When the "pigs" are heated to a high temperature it melts—approximately at about 2750° Fahrenheit—and is then usually poured out into a mould, made of sand or other material, the resulting shaped metal being termed a casting. Cast iron is extremely strong in compression but very weak in tension, or in other words, it takes a much greater force—about six times—to crush it than to pull it apart. For this reason it is used largely for supporting pillars in constructional work and also for the framework of machinery, etc. Cast iron is useless for objects subject to bending.

There are two common varieties of cast iron, known as white and grey. White cast iron is smooth and white, while the grey variety has a comparatively rough surface, but has the advantage of being easier to work. Small iron castings should be made of grey iron.

Malleable cast iron is ordinary cast iron treated by burying the casting in an oxide of iron called red hæmatite. The casting is placed in a furnace and is kept red hot for a length of time according to the size of the casting.

Wrought Iron or **Malleable Iron** is made from cast iron after all the impurities have been removed. It is fibrous in texture, tenacious and soft, and is therefore easy to work. It can be forged into shapes, hammered, drawn or rolled into sheets when heated up to a cherry-red colour. Wrought iron contains not more than 0·25 per cent. of carbon, and its strength is nearly equal in tension and compression; its melting point is 3250° F. This kind of iron is used extensively for ornamental work, horseshoes, etc.

Steel contains more carbon than wrought iron but has less carbon than cast iron. There are two common kinds of steel, called soft or mild steel and hard steel. The former has a fine, bluish-white colour and can be filed, drilled, or turned quite easily. Mild steel is used largely for making parts of machinery and engines, and for structural purposes. Hard steel or cast steel, such as that used in making tools, can be cast, forged, tempered and hardened by first heating it to redness and cooling it in water. As the amount of carbon in hard steel determines its hardness, the steel used in making a razor blade, which must have a very keen edge and is therefore hard and brittle, contains more carbon in its composition than that of the steel used for making a cold chisel, which does not require such a sharp edge but much greater strength. Hard steel is difficult to work, so that it is usually annealed or softened by heating the metal to a red heat and gradually letting it cool off before being worked upon. The more slowly the metal is allowed to cool, the softer it will be.

Copper is an extremely ductile and malleable metal, for it can readily be hammered to shape when cold. It can be rolled into thin sheets, and it can also be forged and cast but not welded. It is an excellent conductor of heat and electricity, and is extensively used for making electrical apparatus, electric cables, steam tubes and in making alloys. The melting point of copper is 1996° F.

Brass is a yellowish-coloured alloy made by mixing copper and zinc together when they are in a molten state. It has many different qualities depending upon the amount of copper and zinc the alloy contains. Ordinary common brass, for instance, contains about 65 parts of copper and 35 parts of zinc. Brass is malleable and ductile but harder than copper. It is specially useful for making small cast parts of machines. It is easy to drill, turn, file and solder.

Lead has a bluish-grey colour and is the heaviest and softest metal. It melts at a low temperature—620° F.—and has great resistance to the action of most acids. It is used largely for making cold-water pipes, coverings for electric cables, chemical tanks, and electric storage batteries. Lead is extremely ductile and can be easily cast.

Zinc is a bluish-white metal used principally for making alloys. It is also employed in the process of galvanising iron. The melting point of zinc is 785° F.

Aluminium is one of the lightest common metals known. It is ductile and quite easy to work, but it has a nasty knack of sticking to the tools. It can be drawn into wires and hammered into sheets; it can also be cast into shapes.

Aluminium is a difficult metal to solder unless a special flux is used. It is not a particularly tough metal, but hardens a lot when worked and requires frequent annealing. The hardness and tensile strength of aluminium are equal to those of any metal except steel.

Duralumin is an alloy consisting of 96 per cent. aluminium, 3 per cent. copper and 1 per cent. magnesium.

Tin melts at a low temperature, 440° F., and as it does not rust it is one of our useful metals. Tin is chiefly used for making alloys, such as type metal, solder, etc., and also for coating thin sheets of iron, called tinplate.

Bronze or **Gun-metal** is a reddish-yellow coloured alloy, and is composed of about nine parts of copper to one of tin. It is used extensively for bearings of machinery and pinion wheels.

Phosphor Bronze is an alloy consisting of ordinary bronze with the addition of 2 per cent. to 4 per cent. of phosphorus. Its tensile strength is greater than that of ordinary gun metal.

Manganese Bronze is an alloy of bronze and ferro-manganese. It has about the same strength and toughness as mild steel and can be forged and rolled. As it resists the corroding action of sea-water it is largely used for ships' propellers.

Type Metal is an alloy of lead and antimony that does not shrink when cast. Clean and sharp small castings can be made quite easily by melting the alloy in a plumber's ladle over a gas-ring or fire.

METAL-WORKING TOOLS

METAL-WORKING tools can be divided under two heads—hand tools and machine tools. The former comprise all the various cutting and other tools which can be hand-applied to the work, while the latter include such machines as lathes, drilling machines, emery wheels, shapers, etc.

The following paragraphs give a brief survey of the tools most commonly used in amateur metal-work.

Hammers come first on the list. These are not the kind the carpenter uses. They are specially shaped for metal-working (engineering). The most useful are those shown in Figs. 1, 2, and 3. The cross-paned hammer (1) is the most useful of all. It should have an ash shaft, and it is advisable to have two sizes—one having a head weighing about ½ lb. and another with a 1-lb. head.

The round-paned hammer illustrated at 2 is extremely useful for riveting and hollow work. Such a hammer having a ¾-lb. head will be found serviceable for general work.

The straight-paned hammer (3) is not so much in general use as the tools mentioned above, but is very valuable for awkward jobs where a cross-paned tool could not be conveniently used.

If heavy work on the anvil is contemplated, a small sledge-hammer may be required. One of 4 to 6 lb. weight will be the most useful, and it should be fitted with an ash shaft of about 2 ft. to 2 ft. 6 in. in length.

An Anvil is an extremely useful tool in the metal-worker's shop but, unfortunately, such tools are expensive. A 28-lb. cast-iron anvil with a chilled face is handy for work of a light nature, if carefully used. A small wrought-iron steel-faced anvil is the proper tool for heavy work but will cost about twice as much as the cast-iron type. An anvil should stand on a solid block sawn from a tree-trunk. The latter should be at least 8 in. in diameter by about a foot high, standing on a foundation of sand. A serviceable type of anvil is illustrated in Fig. 4.

The Vice.—You will not be able to proceed very far with metal-work without the aid of a suitable vice, for if you wish to saw a piece of metal the material must be rigidly and firmly fixed to the bench.

Fig. 5 shows a useful type of engineer's parallel-jawed bench-vice. It consists essentially of two jaws, a screw, and a base. The back jaw is stationary and is in one piece with the base. The front jaw is the movable one and it can be either opened or closed by the movement imparted by the steel screw. Suitable holes are provided in the base for fixing the tool to the top of the bench. The work is placed between the jaws and the screw tightened up in the same manner as a carpenter's vice.

The jaws of most good parallel-type vices are fitted with hardened steel strips having roughened faces. The strips are let into the castings and secured in position at the tops of the jaws by means of countersunk-headed screws. This desirable feature ensures a perfect grip on the work and allows the pieces to be easily replaced when worn.

Quite a lot of useful work can be accomplished in a vice having jaws 3 in. wide which will open to about the same extent.

Smaller vices for screwing to a table by means of a wing bolt are to be obtained, and prove very useful for gripping very small work.

An important point to observe when using a vice is to fix a pair of soft metal clamps between the jaws when working upon finished surfaces, otherwise the work may be badly marked by the hardened jaws. Fig. 6 illustrates a pair of clamps suitable for the purpose, which can be easily made of tinplate, sheet lead, or brass.

When purchasing a vice do not be tempted to buy one of the fancy types which combine anvil, pipe-grips, bending jigs and a host of other devices. They are generally of inferior quality and are expensive. Avoid also "quick grip" vices. Only the best of these are good, and the extra outlay is only justified in cases where they are used on repetition work.

Files are to be obtained in a wide range of size, section and cut. The most useful are the "bastard" cut, in half-round, round, and flat; they should be from 7 to 12 in. in length. Small sizes can be had in the same sections and in three-square and square for small work.

Chipping-chisels, sometimes called cold chisels, will be found very useful for numerous purposes such as roughly shaping a piece of metal before finishing it off with a file, cutting off pieces of sheet metal, cutting grooves, etc.

There are several types of chisels, each useful for its particular purpose. The flat chisel illustrated at A in Fig. 7 will suffice for ordinary work, and for general roughing-out the cross-cut chisel represented at B will be most useful. Both types can be had in various lengths and widths of cutting edge.

Unlike the woodworker's chisel, the metal-worker's flat chisel has two bevelled faces which form the cutting edge; the angle formed is more obtuse than that of the carpenter's tool.

A Bench-drill (Fig. 8) should be included in every metal-worker's outfit. A useful size is one to drill holes up to ⅜ in. diameter and having a 3½ in. vertical travel. A machine having a self-feed is to be preferred to one fitted with a hand-feeding device only, and is well worth the little extra expense. The drill-spindle should have a self-centering drill-chuck for holding the drills, while an assortment of good quality twist-drills for iron and steel, and straight-fluted ones for brass should be provided.

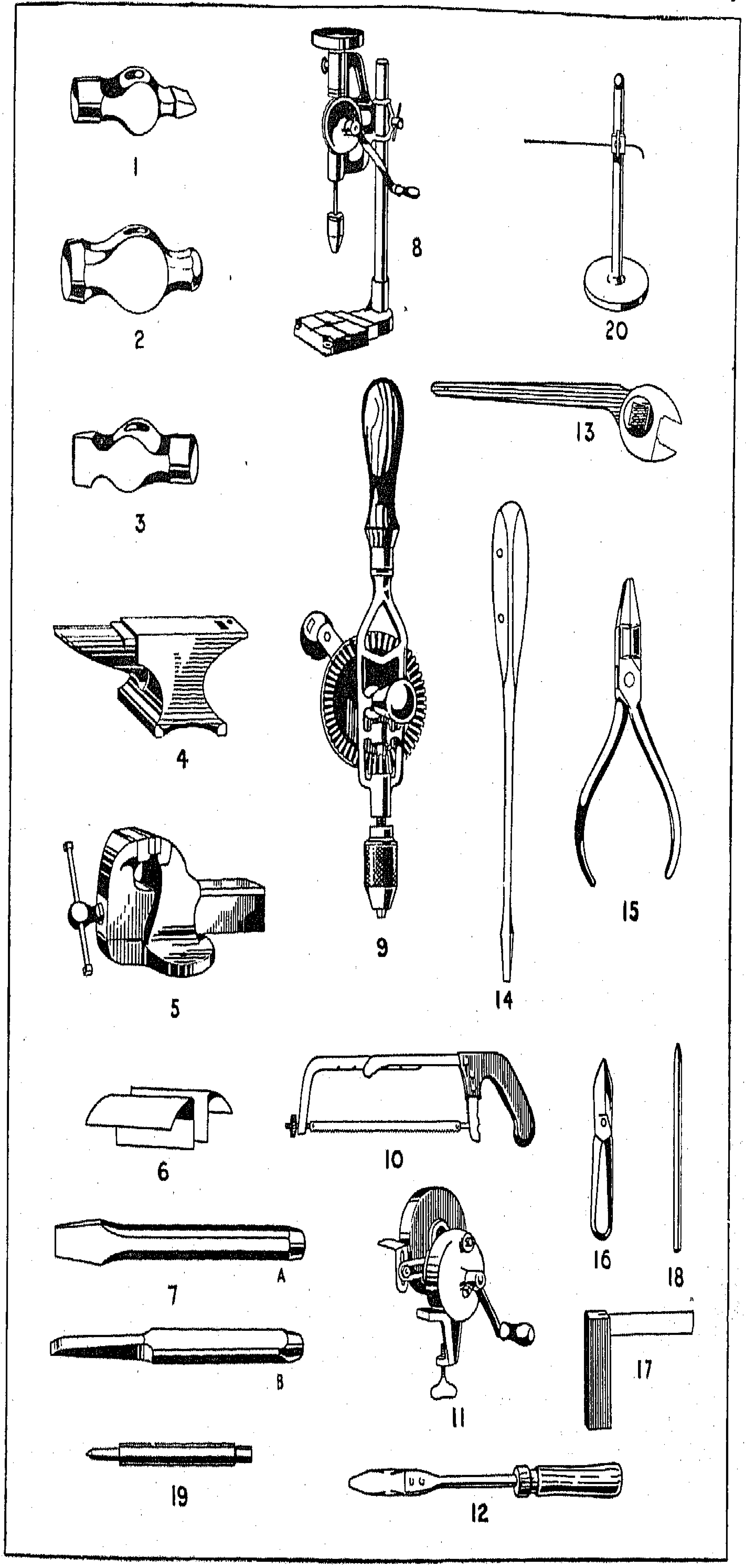
A Hand Drill-stock, as illustrated in Fig. 9, should supplement the bench-drill, as it can be utilised on work where the use of a bench-drill would be impracticable. A hand-driven drill-stock is one of the most useful tools to have in the workshop and can be used for drilling holes up to ⅜ in. diameter.

A good firm hacksaw-frame, with blades, is essential for cutting metal. This appliance consists of a frame into which a saw-blade is fixed and a handle by which the tool is held.

Hacksaw-frames can be had in several types, some being made so that they can be adjusted to suit different lengths of blades, while in another type an arrangement is provided for turning the saw in different directions to cut upwards, downwards or sideways.

A good type of hacksaw with blade attached is shown in Fig. 10. This type combines the two desirable features mentioned above. A glance at the illustration will show that the blade is held in position by means of short projecting pegs arranged at the top and bottom of the frame, the ends of the blades having holes made in them for the purpose. New blades can therefore be put in very easily and quickly. The nut at the top is for tightening up the blade as in a woodworker's fretsaw-frame.

Hacksaw-blades may be obtained in various qualities with either fine or



coarse teeth. There are many excellent ones on the market.

For general purposes, a 9-in. blade is a handy size to use. For cutting mild steel and cast irons, etc., choose a blade having about 14 teeth to the inch, while for sawing hard steel a finer degree of coarseness is recommended—say 24 to the inch. For all-round work a blade having 18 teeth per inch will be found quite suitable.

The way to use a hacksaw is to fix the work firmly in the vice—close up to the jaws to obviate vibration as much as possible—at about the height of the elbow when you are standing upright. Insert the blade into the frame so that the teeth cut on the outward stroke, that is, away from the operator. Tighten up the tension-nut tightly, as the blade should be rigid. Grasp the handle of the saw in the right hand and grip the other end at the top with the left, holding it perfectly straight. Now gently push the tool forward on the work, using a steady, even pressure right to the end of the cutting stroke; then relieve the pressure and draw the tool back to its original position. Repeat the process until the metal is nearly severed, when the pressure should be gradually relieved.

You will find it an advantage to make a nick in the metal with a file at the required position before beginning the cut, as this precaution will prevent the saw sliding sideways on the first stroke.

One of the chief points to observe when using a hacksaw is not to twist the blade, otherwise the inevitable result will be a broken blade, because hacksaw-blades are hard and brittle. Another observation to note is that the speed for cutting varies with different metals. When cutting iron or steel the number of cutting-strokes per minute should be in the neighbourhood of 75. Some workers prefer to lubricate the saw-blade. This is unnecessary and generally causes the teeth to slide over the work instead of biting into it.

For sharpening tools a wet grindstone is still the best tool, but it is expensive. A small emery grinder to clamp on the bench (as illustrated in Fig. 11) is now largely used. In selecting an emery grinder the essential point is to see that it can be easily rotated at a very high speed. The higher the speed the less the wear of the wheel. Foot-operated emery wheels are, of course, to be preferred to hand-operated ones.

Taps and Dies are the tools used for making internal and external screw-threads by hand. They can be had for cutting Whitworth, B.A. (British Association) and various other standardised screw-threads. A good way to go about the provision of these tools is to buy them separately as required. This method of buying as wanted is cheaper than purchasing sets, which generally contain a number of sizes never likely to be used by home workers.

The method of cutting threads with hand-operated tools is fully explained in a subsequent article.

Soldering-irons.—For soft soldering, a good-sized copper bit (Fig. 12) is necessary. The larger the better, as very small soldering-irons lose heat too quickly to be useful except for the smallest work. A copper bit weighing about ¾ lb. will suffice for general work, including most household repairs requiring an application of solder.

The bit should have an iron shaft, flattened, divided and riveted through the copper, and it should have a long beech handle. Avoid a soldering-iron where the shaft is screwed into the copper, as it invariably becomes loose and consequently very awkward to use.

For heating the iron a good clear fire can be used, but an eighteenpenny rectangular gas-heater with an inverted rectangular loaf-tin makes a better and more economical heater for the iron.

A blowlamp, using either paraffin or petrol, may be rigged up to heat the soldering-iron, with a little ingenuity.

Electric soldering-irons are ideal where current is available, as the bit is self-heating.

Spanners are necessary for amateur engineering work. The adjustable type of spanner is useless unless of good make. A useful wrench for awkward corners is the engineer's favourite "Clyburn," illustrated in Fig. 13. A 6-in. size has a span of ⅝ in., while a 10-in. one has a span of 1 in.

It is advisable to have a set of thin double-ended spanners. A set of such spanners will fit eight sizes of nuts for Whitworth bolts from ⅝ in. to ¾ in. diameter.

"Quick grips" are useful for pipe work, stud extractions and work of a similar nature. The "foot-print" grips are the best.

For the motor-car owner who carries out the majority of his own repairs a set of box spanners is almost indispensable. A set of four double-ended box spanners and a tommy bar for turning them will deal with nuts from $\frac{3}{16}$ in. to ⅝ in.

Screwdrivers for engineering work should have extra strong handles. A suitable type where the blade and handle are in one, with wooden sides secured with rivets, is represented in Fig. 14. The ordinary joiner's screwdrivers are not suitable for engineering, neither are the various kinds of ratchet screwdrivers.

Fig. 15 illustrates a useful pair of square-nose pliers with side cutters for severing wire. At least two such tools should be included in the metal-worker's outfit, one about 6 in. long for dealing with large work and a lighter one for small work.

A Pair of Hand-shears is necessary for cutting sheet metal. This useful tool is shown in Fig. 16 and requires little explanation. It is very much like a pair of scissors, except of course that it is much more robust. Several patterns of shears are to be obtained, but you will be well advised to get a pair of straight "snips"—as the tool is often called—8 in. long, which will give a cut of about 2 in.

The Engineer's Rule is made of steel. This is necessary because very accurate measurements are generally required. Such rules are sometimes provided with metric as well as English scales. The metric scale is divided into centimetres and millimetres, while the English scale is in inches and subdivided into eighths, sixteenths, thirty-seconds, and sixty-fourths of an inch. A 6-in. rule is a handy size for small work, but for larger work a 12-in. rule will be required.

The Engineer's Square (Fig. 17) is also made entirely of steel. It is used, of course, for setting off lines on a surface at right-angles to a given edge, testing accuracy of work, etc., in the same way as a carpenter's square is used on wood.

A good type of square for general work should be provided with a thin blade about 4 in. long fitted to a thick stock.

The Scriber.—As a pencil cannot be conveniently used for marking metal, the necessary marks are made by means of a scriber such as that shown in Fig. 18. The tool, in its simplest form, consists of a thin rod of hardened steel, one end of which terminates in a sharp point. A scriber of this type is easily made with a length of ⅛-in. diameter silver steel rod about 8 or 9 in. long, by filing or grinding one end to a sharp point and then hardening the tool.

Dividers suitable for metal-working have a spring head and side adjusting screw which provides a ready means of making accurate adjustments.

The Centre-punch (Fig. 19) although small in size is nevertheless an important tool. It is used principally for marking the centres of holes for drilling, marking out a piece of work preparatory to filing, sawing, etc.

Centre-punches are made of hardened steel, one end being ground to a point. For heavy work the point is ground to an angle of 45°, while a sharper pointed tool, having an angle of 60°, is used for work of a lighter nature.

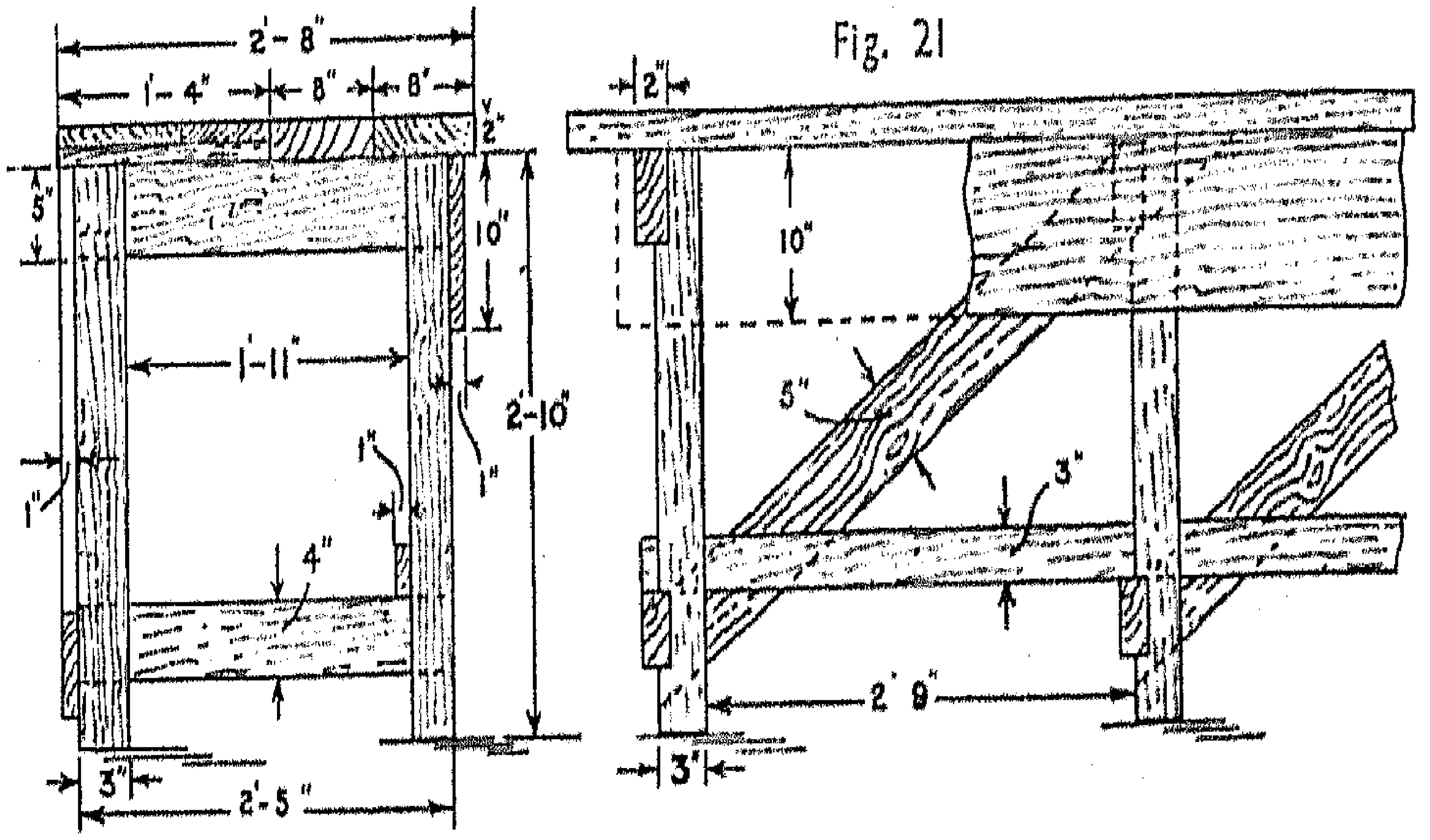


Fig. 21

The Scribing-block.—Where much fitting and turning is to be done, a scribing-block—or surface gauge—is necessary. It is generally used in conjunction with a surface-plate for accurately marking out pieces of metal previous to being worked upon. A simple form of surface-gauge is the one shown in Fig. 20. It consists of a vertical pillar—usually of mild steel—fixed into a circular base, the under surface of which is undercut to ensure a perfectly true bearing surface. A scriber is fastened to the rod by means of a clasping device provided with a wing-nut which allows the height of the scriber to be adjusted to any desired height and angle.

The professional engineer's surface-plate is generally in the form of a heavy iron casting having a perfectly flat and true surface. It is used for laying out work and for testing the accuracy of flat surfaces.

Surface-plates are very expensive to buy, and for this reason are seldom used by the amateur mechanic. A good substitute for such a plate is a piece of thick plate glass supported by a wooden framework or base.

The Bench, if possible, should be built into the wall of the workshop, since a deal of wrenching and bending is often necessary, which would pull a detached bench about the floor. If it is not possible or desirable to fix the bench to the wall, it may be screwed to the floor with strong angle-brackets. A suitable construction is shown in the drawing (Fig. 21), which illustrates the arrangement of the legs, bearers, rails, etc. Suitable dimensions are shown, except length, which will be such as to suit the space available. The little extra outlay in having stout frame- and top-members will be well invested. Finish is of no great importance except on the front and top, which should be planed. The rest could well be left rough as from the mill, but planed up if a neater finish is desired. Great strength is the prime importance, especially at the leg which supports the vice.

An engineer's bench should be of such a height that, with the vice fitted, the top of the vice will be 3 ft. 4 in. above the floor level. Since the vice will stand about 4 in. above the bench, the bench-top will be 3 ft. high.

Reference to the drawing shows that the legs are 2 ft. 10 in. long and 3 in. square. The top rails are 2 ft. 5 in. by 5 in. and 2 in. thick. They are let into the sides of the legs to a depth of 1 in. The bottom rails are 4 in. wide and of the same thickness and length as the top ones. The legs are placed at suitable distances apart to suit the length of space available. For a small bench three pairs of legs 2 ft. 9 in. apart will be suitable. 3-in.-wide rails are fixed against the legs behind and above the bottom rails along the full length of the bench, and diagonals are nailed on the back as shown in the side and front views. The diagonals are cut from 1-in. stuff and are 5 in. wide.

The top consists of two sound deal planks, 2 in. thick and each 8 in. wide, and two similar ones of 1 in. material. The front planks are laid direct on the top rails or bearers and screwed down. The 1-in. boards are fastened to strips of 1-in. stuff supported by the bearers to enable the tops of all four boards to lie flush when screwed down. The large members of the bench should be screwed together—not nailed.

The Front Board, which is 10 in. wide, may be dispensed with if desired, or a narrower one used in its place. It is an advantage to retain it as it stiffens the bench, gives a better appearance, and is useful for boring holes in which it may be handy to support work—pipes, rods, etc.—while being worked on in the vice.

The vice should be firmly screwed or bolted down over one of the legs. Generally, an end leg is found most convenient, but the question of light may prove the most important factor in deciding the best position.

THE METAL-TURNING LATHE

THE metal-turning lathe has been rightly designated the "King of Tools"; and as it is such an important machine tool in the art of metal-work, it is not surprising that a complete volume could be written about it. The present article, however, is only intended as a brief guide to the methods of using small lathes suitable for such work as model-making, small work in connection with motor-car repairs, and jobs of a like character.

There are numerous types and sizes of lathes—ranging from the tiny machine used by the jeweller to the huge tools employed in heavy engineering—varying in details but all possessing certain essential features such as the bed, head-stock and tool-rest.

In order to drive a lathe some form of driving-gear is necessary, which, for a small machine, is operated by foot-power, transmitted by a treadle. This method of driving the lathe answers the purpose quite well if the machine is only used occasionally, but when the lathe is constantly in service, a lot of labour will be eliminated by driving the lathe by means of a small electric motor.

Small lathes may be divided into three classes: the plain lathe, the back-geared lathe with a slide-rest, and the screw-cutting lathe.

The plain lathe, in its simplest form,

consists of a headstock and a tailstock mounted on a bed which is fixed either on a pair of legs or standards, or a suitable bench. The mandrel or spindle which imparts motion to the work is driven direct by a belt and pulleys without any intervening gear. A plain T tool-rest is generally provided for use with hand-operated tools.

A better and more useful type of plain lathe is fitted with a slide-rest, which allows the tool to be fixed rigidly in a holder attached to a slide which is movable in two directions by means of two screws and handles. This refinement greatly increases the scope of operations, and makes the production of accurate work a much easier matter than that entailed by the use of hand-operated tools. Such a lathe can be used successfully for light work in brass, gun-metal and steel.

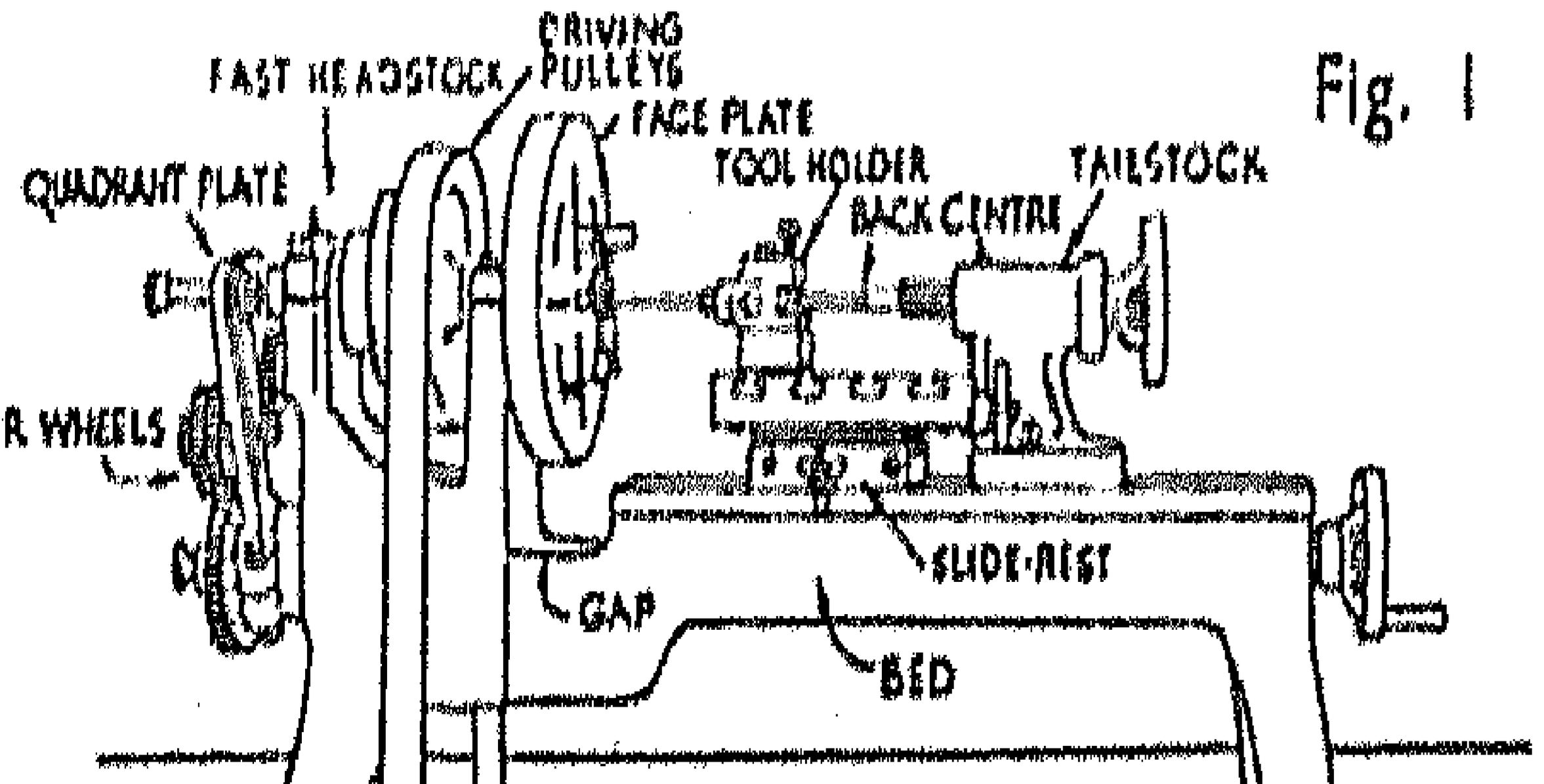


Fig. 1

Although good work of a light description can be turned out on a plain lathe, there is a limit to its use, for when heavy cuts have to be made, or work of a large diameter has to be turned, a back-geared lathe, which is usually provided with a gap in its bed, is essential.

The Back-geared Lathe differs from the plain lathe in having gearing incorporated in the fixed headstock to reduce the speed of the mandrel. This reduction in speed is a great advantage when the lathe is required for machining rough castings or other comparatively heavy work where a slow speed is essential. The back-gear is adjustable so that it can be thrown out of action when the mandrel is required to be driven direct from the pulleys.

The Screw-cutting Lathe is the most useful kind of machine for all general purposes. It may be fitted with a back-gear, or it may not, but it certainly has the great advantage of being able to cut screw-threads and to impart a self-acting sliding motion to the tool in the slide-rest. These desirable results are obtained by means of a "lead"—or "guide" screw, as it is sometimes called—running along either in front of or within the bed of the machine, and operated by a suitable train of gear-wheels driven from the mandrel.

The rotation of the lead-screw, when it engages with a special nut on the saddle, upon which the slide-rest is mounted, causes the saddle to travel along the bed. This movement of the saddle can be varied in speed by manipulating various-sized gear-wheels driving the lead-screw. This alters the travel of the saddle in relation to the spindle, so that threads of any desired pitch may be cut upon the work. If the train of wheels is so proportioned to give a very slow action to the saddle, it follows that the lead-screw may be used for automatically traversing the tool for ordinary turning, or, in other words, the cutting-tool will be "self-acting."

Fig. 1 shows a useful type of small screw-cutting lathe, the various parts of which are shown clearly in the illustration.

The Foundation.—As the accuracy of the work depends almost entirely upon the accuracy of the machine—apart from any lack of skill on the part of the operator—it follows that the foundation or bed must be "dead" true. This high degree of precision is obtained in the main by accurately planing and scraping the working surfaces of the casting of which the bed consists, and enables the saddle to be moved along it without any play whatever. The inside edges of the channel or slot in the bed form a true guide for the tailstock when moved to any desired position.

Although the flat-section type of bed is not common to all lathes, it is a good type to have. Some makers of small lathes make their lathe-beds in the form of a round bar, but whatever the shape of bed may be, it must be dead true.

The Gap (shown clearly in the illustration), is one of those small details which makes all the difference in machine tools such as the lathe, as it greatly increases the capabilities of the machine by allowing short jobs of large diameter to be operated upon.

The Bed is usually supported either by a pair of short legs for bolting down to a bench, or a pair of standards forming an integral part of the lathe. In each case the foot-motor for supplying the necessary power is placed under the lathe.

The Fixed Headstock must be strong and rigid, for it carries the revolving spindle or mandrel, the driving-pulleys and the back-gear, if fitted. It is one of the most important parts of the lathe, and it may be a heavy iron casting fixed securely to the bed by means of a bolt or other locking device, or it may form part of the bed casting, as in the case of the lathe shown in the illustration.

The Tailstock—or poppet head, as it is sometimes termed—is also an iron casting, but capable of being moved to and fro along the lathe-bed to suit the length of the work. It is then screwed in position by a bolt passing underneath the bed. Its principal use is to carry a hardened steel back centre, which is held in position by a tapered hole bored in the spindle. The spindle, which must be a perfect fit in the barrel and quite rigid when in use, can be adjusted backwards and forwards by means of a wheel or a handle operating a screw. A screwed locking-pin is provided for locking the spindle when it has been moved in or out to the desired position.

The Sliding-carriage which carries the slide-rest is known as the saddle. It is essential that this component move along the true surfaces of the bed without any play or rock, otherwise inaccurate work will result. The saddle is moved along the bed by either a guide-screw or by a rack-and-pinion-gear.

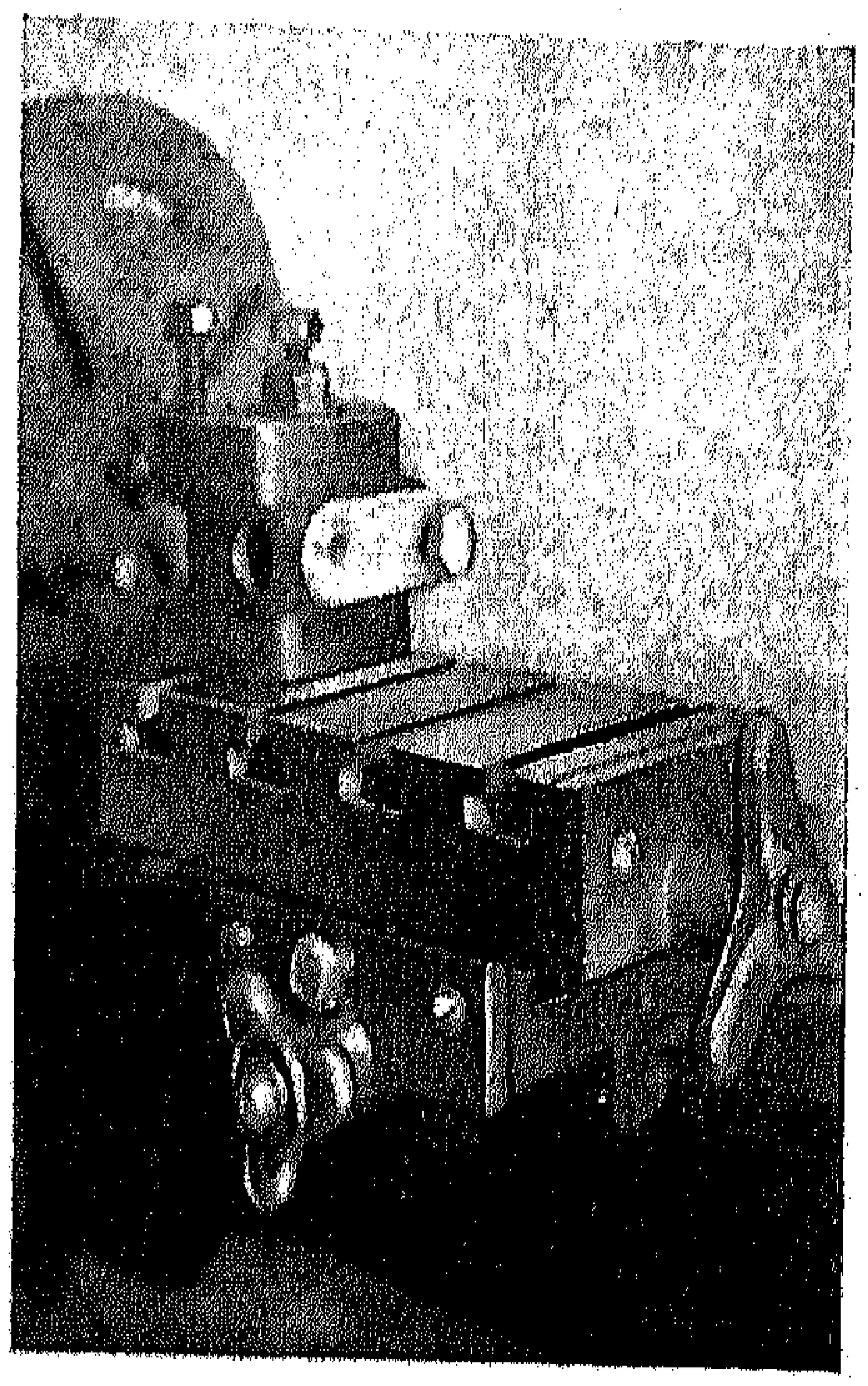


Fig. 2

The Slide-rest (shown in Fig. 2), consists of two main parts known as the cross- or bottom-slide and the top-slide. The former consists of a sliding member which can be moved to and fro across the width of the bed by a screw operated by a suitable handle. The cross-slide is usually provided with a number of ⊥-shaped slots running across it which serve a very useful purpose, for, when the top-slide is removed, it forms a convenient table upon which work can be bolted down. This is done by sliding the heads of the fixing-bolts into the slots. The top-slide is fastened down to the cross-slide, and carries the tool-post. Its normal movement is parallel to the length of the lathe-bed, but as taper-turning and boring is often required, it is usually made to swivel round to any angle. Movement to the top-slide is obtained by a screw operated by a handle.

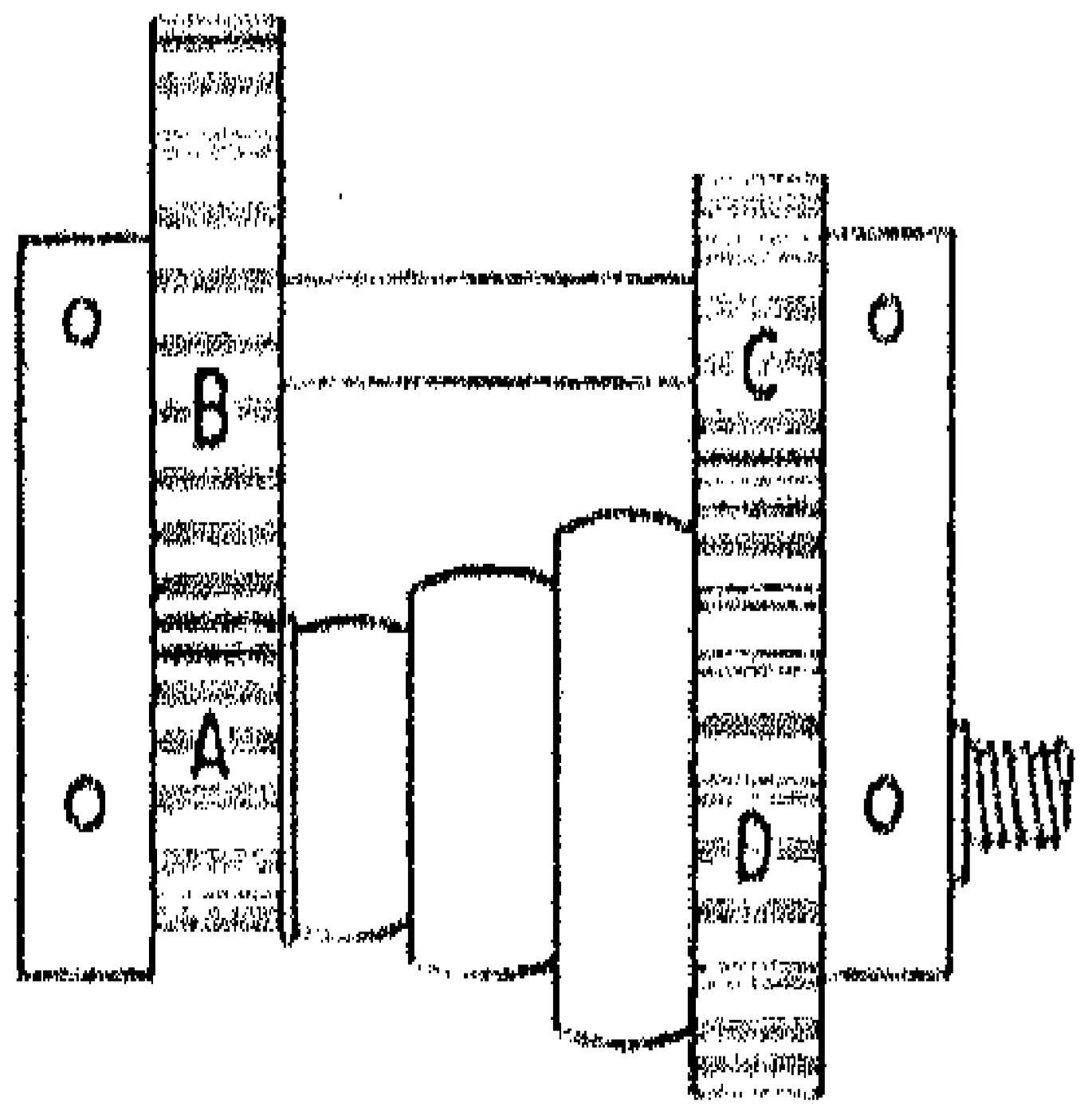


Fig. 3

The Tool-post is where the turning-tool is held, which, in the one illustrated, is fixed by means of two set-screws.

The Mandrel—or spindle, as it is sometimes called—is another important part of the lathe, for it must run perfectly true in its bearings, without any suspicion of shake. The spindle may be either solid or hollow—that is, with a hole bored right through. The hollow mandrel is a great advantage as it allows long pieces of rod to be inserted and held in a chuck. A three-step pulley is fixed to the spindle which revolves between the bearings in the fixed headstock. The projecting part of the mandrel—professionally known as the "nose"—is bored out to form a tapered hole which holds the "live" or revolving centre. It is essential that the centre be truly placed or it will not run truly when the mandrel revolves. The nose is screwed externally to carry chucks or other accessories it may be necessary to use.

In some lathes a driver-plate or catch-plate, consisting of a disc with a projecting pin, is screwed on the mandrel nose for driving work between centres, but in the lathe illustrated the same object is attained by a stud secured to a face-plate.

When large-diameter work is being turned or heavy cuts are being made, it is usual to reduce considerably the speed of the mandrel. This is accomplished in the best machines by a back-gear, a diagram of which appears in Fig. 3. It consists of a small pinion or toothed wheel, A, fixed to the belt-pulley, which meshes into a larger wheel, B, fixed to a spindle at the back of the headstock. This back-gear shaft carries at the other end another small pinion, C, which drives back on to a large-toothed wheel, D, keyed to the mandrel. The back pair of wheels are put in or out of gear by a back-gear handle. A locking device on the large pinion on the mandrel has also to be operated when the gear is changed.

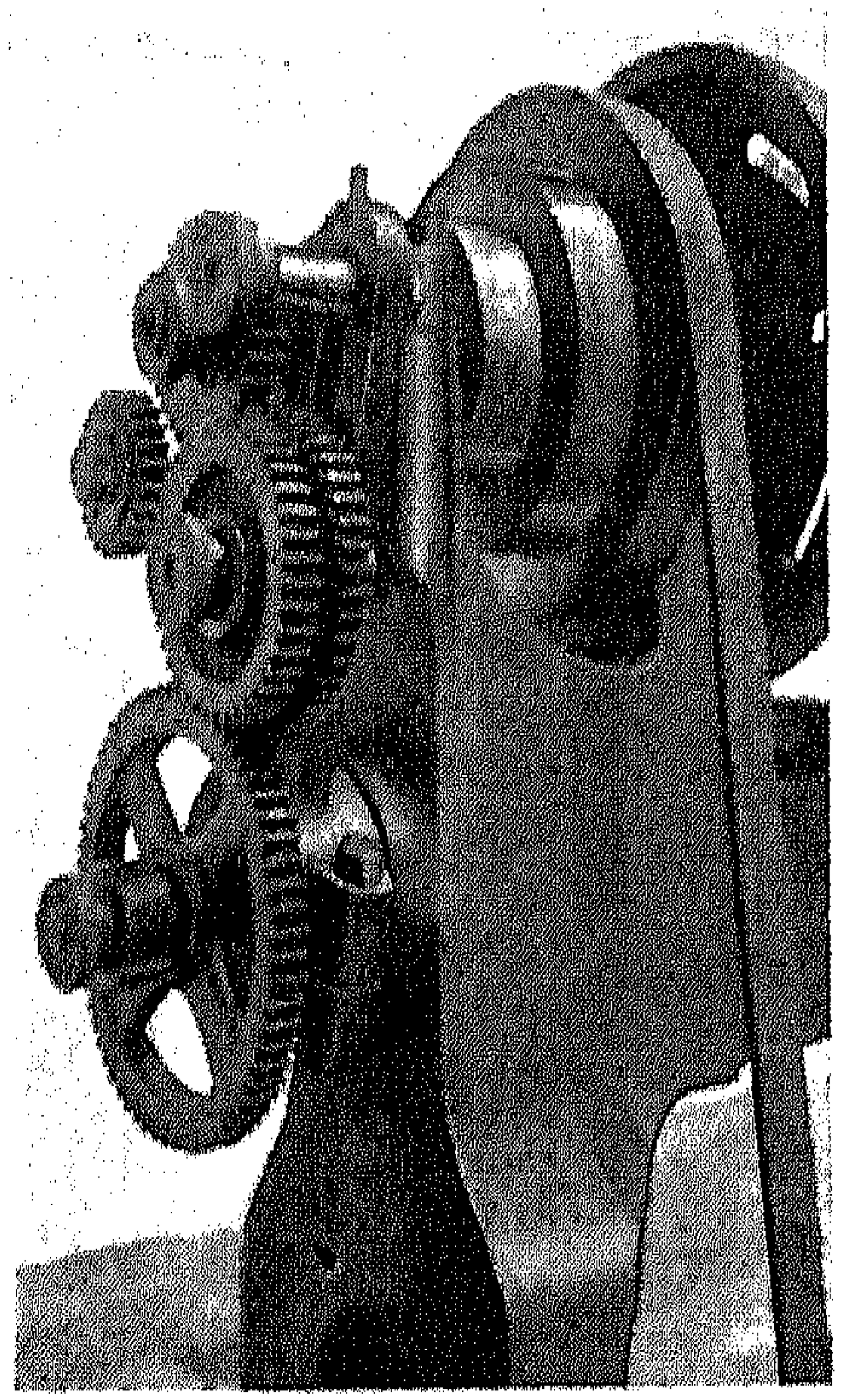


Fig. 4

The Train of Gearing, known as change-wheels, transmits motion from the spindle to the lead-screw. A full set of wheels—generally consisting of 22 wheels, ranging from 20 teeth to 120 teeth—is usually provided with the best kinds of lathes, but in the cheaper types a full set is not supplied. The wheels are fitted on an adjustable bracket or quadrant-plate, which is pivoted on the lead-screw. This plate carries a stud—or studs—to which the intermediate wheel or wheels of the screw-cutting gear are attached (as illustrated in Fig. 4).

It is sometimes required to cut a left-hand thread on a piece of work. To do this it is necessary to reverse the direction of rotation of the lead-screw. This is provided for by a slotted bracket projecting from the headstock. The bracket has an adjustable stud for carrying an extra pinion.

The Lead-screw.—The long screw which in some machines runs parallel to the front, and in others within the bed from one end to the other, is the leading-screw, sometimes termed guide-screw. Its purpose is—when in gear—to move the saddle along the bed, and so guide the tool along the work when cutting a thread. The screw, usually of steel, is provided with accurately-cut square threads, the pitch of which varies with the size of the lathe. Small lathes are usually fitted with lead-screws having four, eight or ten threads to the inch. In lathes provided with a lead-screw at the front, the saddle is put into motion or stopped by a handle which opens or closes a nut fixed to the saddle. The nut through which the lead-screw passes is split in two halves and obviously has a thread of the same pitch as the lead-screw. If the handle is operated when the lathe is geared and running, the nut closes and engages with the lead-screw, and the saddle travels along the bed, while an opposite motion imparted to the handle reverses the process by disengaging the nut, and so stops the traverse of the saddle.

The Rack.—To provide a convenient method for moving the saddle from one point of the bed to another, a tooth-rack or saddle-rack is sometimes fitted. The rack is fixed to the lathe-bed, and a small pinion carried on the saddle engages with the rack when the handle is operated, which causes the pinion to rotate and thus give motion to the saddle. This useful arrangement can only be used when the guide-screw is open, but when the lead-screw is in operation the handle rotates automatically. This "self-acting" arrangement is very useful when turning long pieces of work, for it not only enables the work to be performed in a uniform manner, but it also obviates the necessity of using the slide-rest screw.

The chief points to be observed when purchasing a lathe are as follows: For ordinary use it is not necessary to have a very heavy or expensive machine. A $3\frac{1}{2}$–$4\frac{1}{2}$-in. centre lathe should be large enough for all ordinary work of a small size. It should be of good design, robust and rigid, and provision made to enable the wearing parts to be easily adjusted. The lathe should be fitted with a gap, if possible.

Tools.—Although the use of an accurate lathe is essential for the production of high-class work, the proper use of correctly-shaped tools is almost, if not quite, as important.

A good turning-tool properly shaped and correctly applied to the work will cut easily into the metal, imparting an even and smooth finish. An incorrectly shaped tool, however, will give unsatisfactory results, and will tear the metal instead of cutting it, and at the same time will absorb a great deal more power in removing a given quantity of metal. The shape given to any particular tool is governed by the nature of the work it has to do, and the kind of metal to be operated upon. For example, a tool suitable for turning brass is quite unsuitable for turning steel.

The chief points associated with a good slide-rest tool are as follows:

1. The cutting-edge must be sharp enough to cut well and must be strong enough to stand the strain without fracture.
2. Sufficient "clearance" must be given underneath the tool to prevent it from rubbing the work.
3. It must have sufficient top relief to facilitate the removal of the cuttings from the tool.

By referring to the drawing (Fig. 5), which shows a tool for turning wrought iron and mild steel, it will be seen that the various angles have been represented by letters. A is the angle of clearance which has to be provided to prevent the tool rubbing the work; B is the cutting angle. This angle varies according to the metal being turned. For wrought iron, cast iron and mild steel an angle of about 58° is the usual practice, but if heavy cuts are to be taken in cast iron, the cutting angle is sometimes a little more obtuse, to give the necessary support to the point of the tool. C is the angle of "top rake," which slopes backwards from the front of the tool, forming an angle of about 28°. If the tool is used for cutting in one direction only, it is usual to provide side rake in addition, because such a cutting-edge cuts the metal much more easily and takes considerably less power.

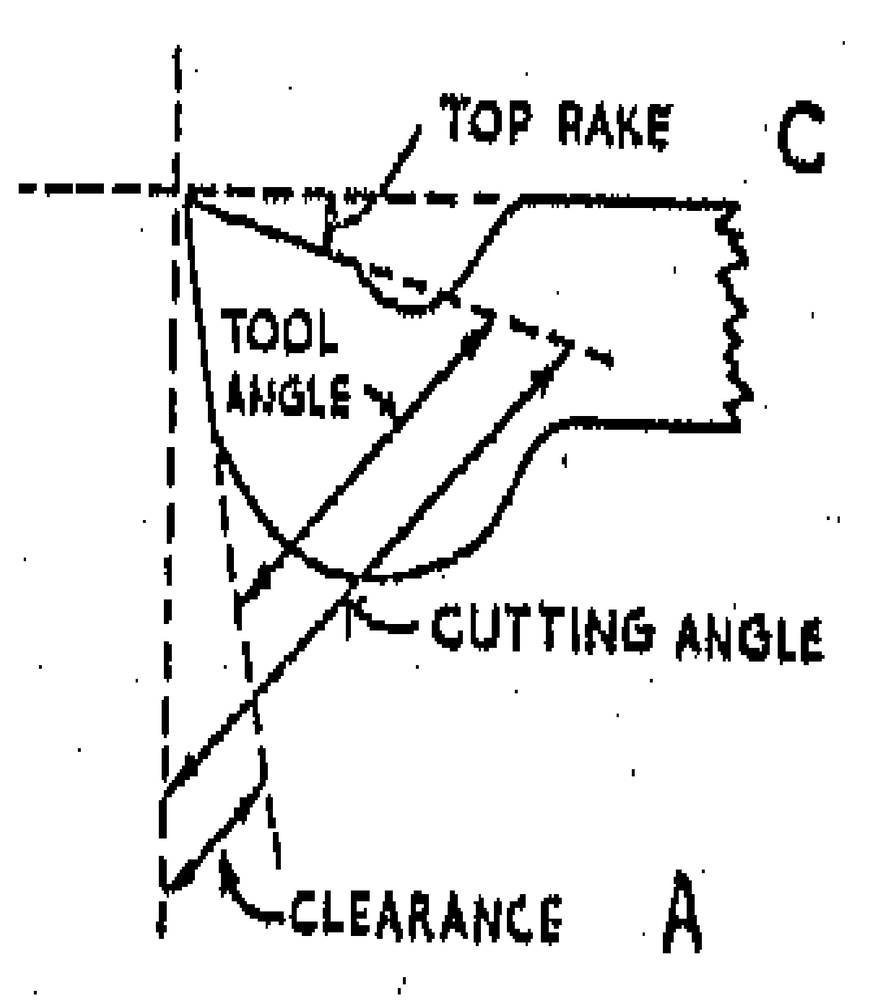


Fig. 5

Another important feature to be observed when using metal-turning tools is that those tools used in a horizontal position must have their cutting-points set level with the centre of the work to ensure the correct clearance and top rake.

Fig. 6 shows a series of drawings of a turning-tool in its right and wrong positions. A shows the tool correctly centred; B shows the tool set too high, with the obvious result that the work will simply rub against the metal; C—here the tool is wrongly placed as the cutting-edge is below the centre of the work. This is a very dangerous position, as the tool is liable to dig into the work and possibly ruin it. It is a mistake to elevate the tool by placing a piece of packing under the front of the body of the tool in order to raise its cutting-edge to the centre of the work. The result of this simply alters the angles of the tool in relation to the work, and causes the tool to rub the metal instead of cutting it. The effect of tilting the tool down results in having too much clearance and insufficient top rake.

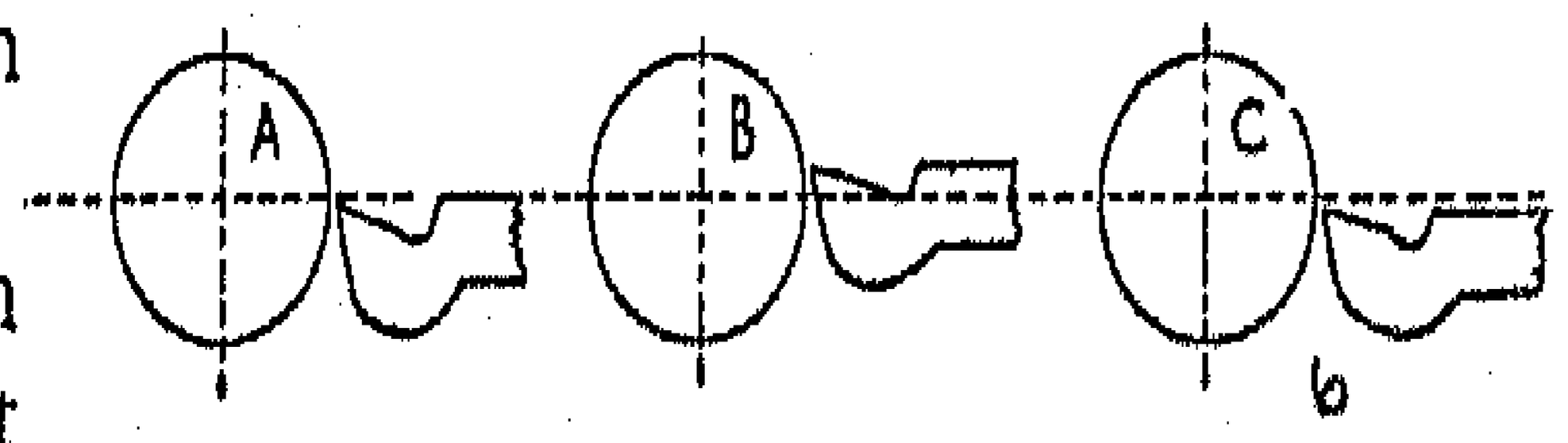


Fig. 6

From the above it follows that when it becomes necessary to raise the tool after it has become worn by constant regrinding, it is advisable to place a piece of flat metal underneath the whole of the body of the tool to keep it in its correct horizontal position.

A Set of Slide-rest Turning-tools for general use with wrought iron and mild steel, consists of the following items, and is illustrated in Fig. 7. A front turning-tool, A, for turning work between centres and for cross-traversing cuts on work in a chuck or on a face-plate. A right-hand and a left-hand side cutting-tool, B, for coping with surfaces which cannot be reached with a front-tool. For facing the right and left sides of work, a right-hand and a left-hand knife-tool, shown at C, is necessary. These tools are used on such work as collars, making shoulders on shafts and for producing sharp corners. A parting-tool, D, is used for cutting channels, and for cutting off the waste from work. Special attention must be paid to the clearance angles of this tool, for unless sufficient side clearance is provided, the tool is liable to stick in the work, which is likely to ruin both the work and the tool. These clearances are clearly shown at E.

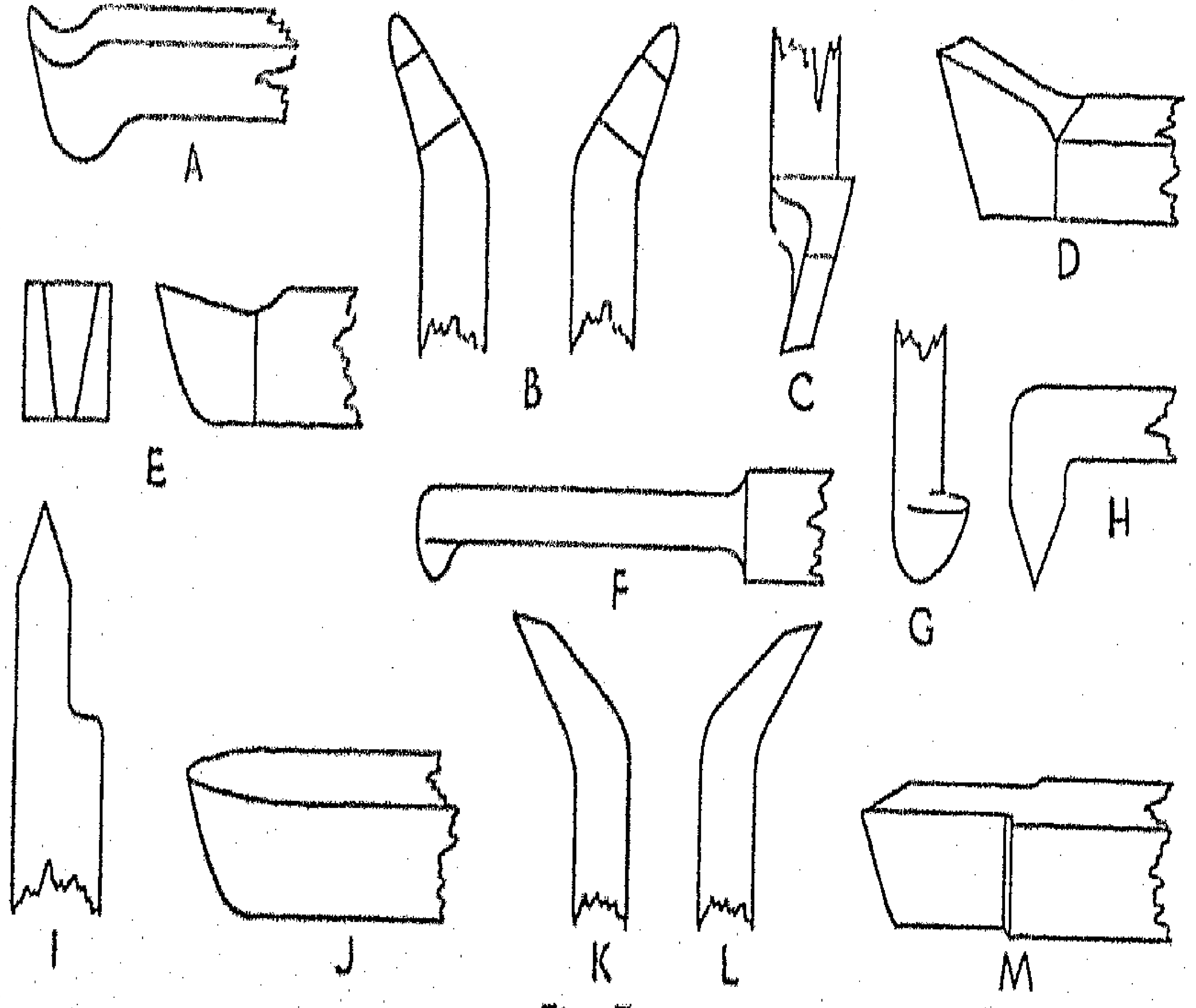


Fig. 7

An Ordinary Slide-rest Boring-tool, F, is used for turning internal surfaces, such as cylinders, etc. This tool must have clearance at the cutting end to enable the tool to finish the cut to the end of the work. If this clearance is not provided, the tool will probably come in contact with the face-plate, or other device holding the work, should there be but little room available between the work and the face-plate. Proper clearance must be made under the cutting-point of the boring-tool, otherwise the tool will rub against the side of the hole. This precaution applies particularly to tools used for boring small-sized holes. This clearance is shown plainly at G.

V-thread Tools are used for forming internal and external V-shaped threads; such tools are illustrated at H and I respectively.

Tools for turning brass and gun-metal are different in shape to the foregoing and do not require top rake. A keen tool is not necessary for turning brass, for if the tool is too sharp it will tear the surface of the metal. To obtain a nice smooth finish on brass, a comparatively blunt tool should be used. A front-tool suitable for brass is shown at J, while K and L represent a pair of side-tools. A parting-tool for brass is indicated at M.

The Slide-rest Tool-holder is illustrated in Fig. 8. This device, of which there are several types to be had, obviates the necessity of using several tools of the solid type previously described.

Small cutters of high speed or carbon steel can be obtained which fit into the head of the holder. The head of the tool-holder is designed to swivel round to any desired angle, and as the cutter is set at an angle it thus provides the necessary clearance and top rake.

As metal-turning demands a very high degree of accuracy—very often to within 1/1000th part of an inch—it follows that accurate measuring instruments are a necessity. A wooden rule suffices for measuring woodwork, where extreme accuracy is not required, but for metal-work of every description a metal rule should always be used. A 12-in. and a 6-in. steel rule, subdivided into eighths, sixteenths and sixty-fourths of an inch are handy sizes for general work.

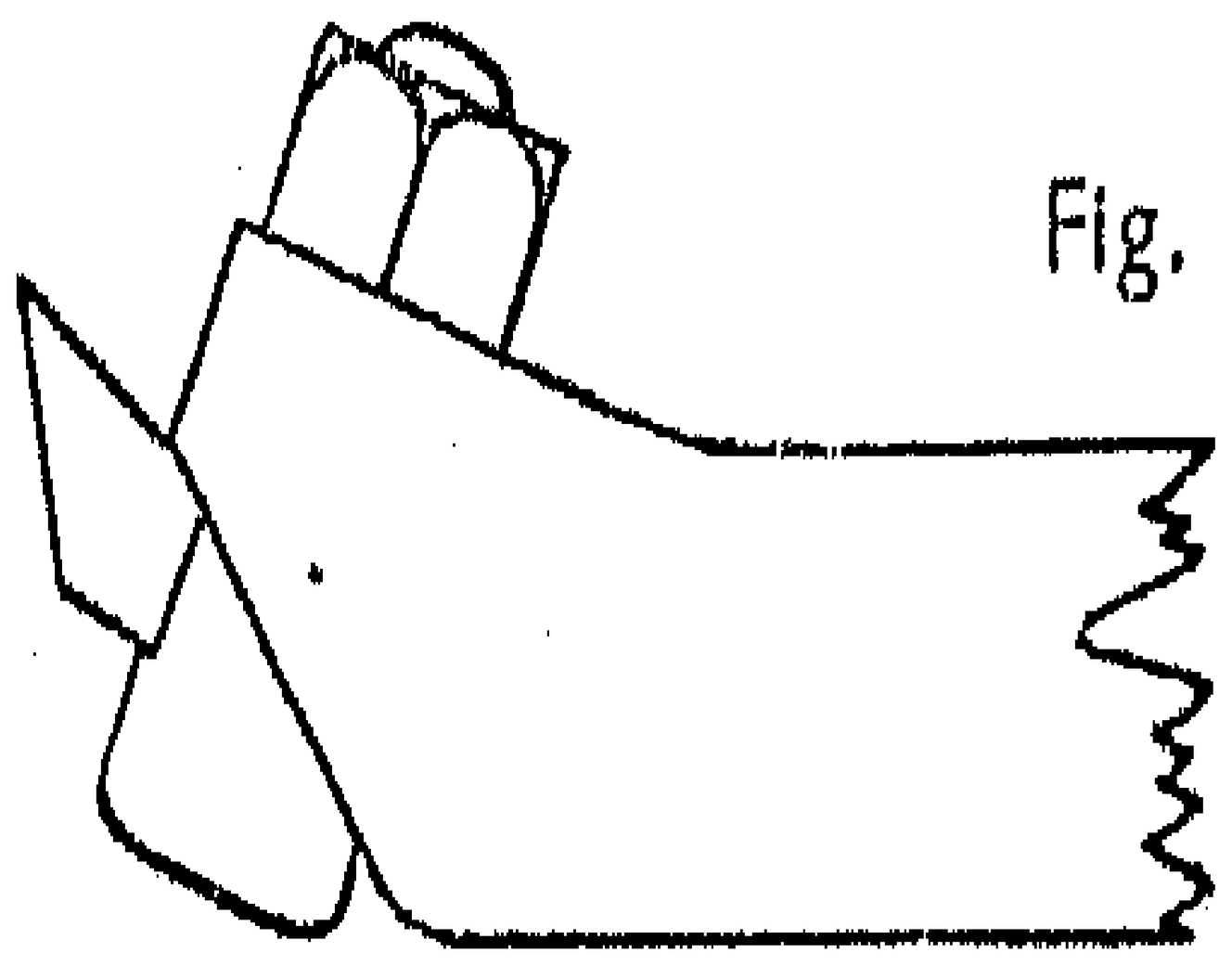


Fig. 8

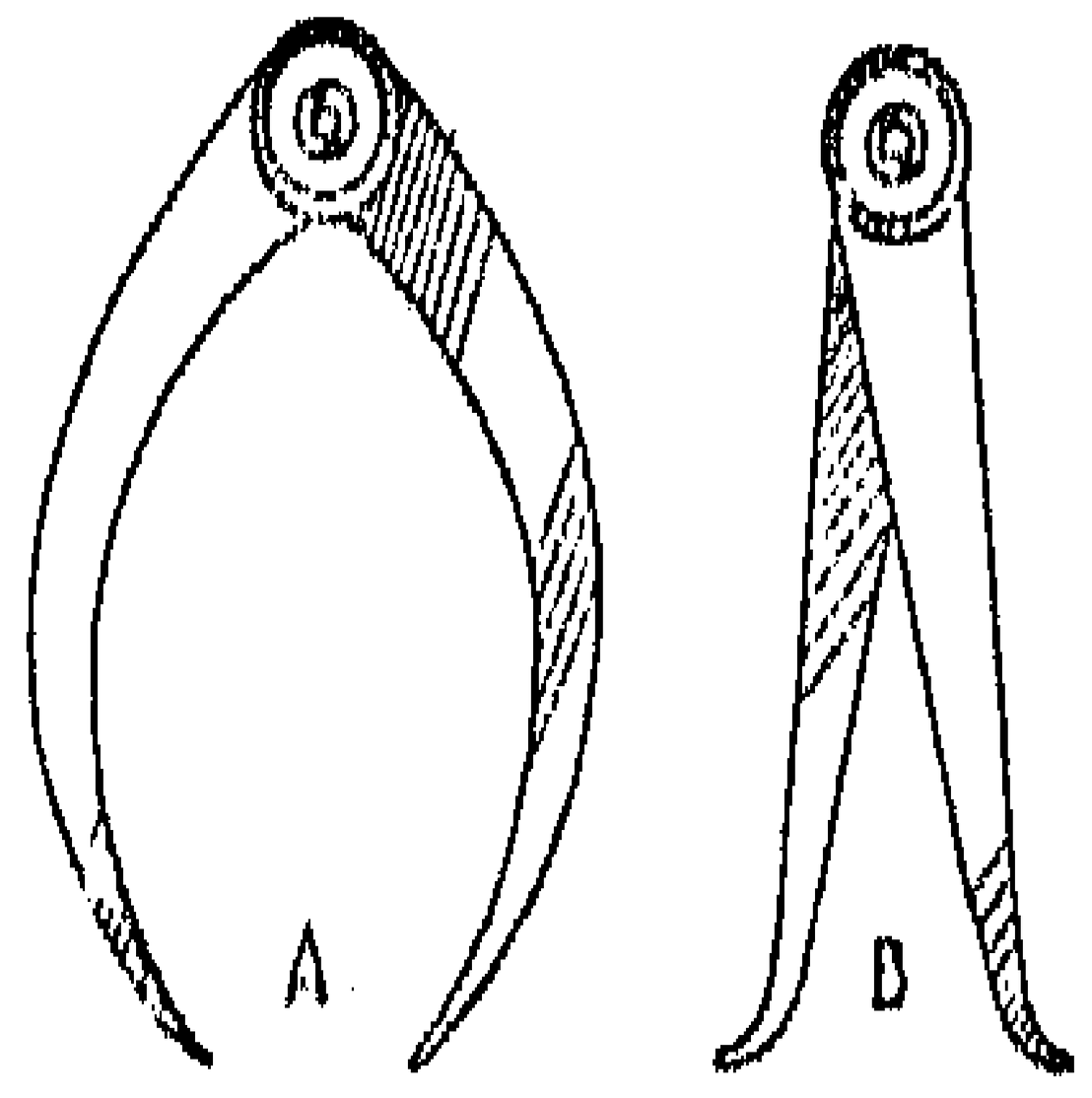


Fig. 9

For measuring external and internal diameters, several pairs of callipers should be included in every metal-turner's kit. A pair of callipers for measuring external diameters is shown at A in Fig. 9, and B illustrates a pair of callipers for ascertaining internal diameters. Another type of callipers, having odd-shaped legs—usually called "Moph" callipers (*see* Fig. 17)—is useful for marking centres on round material. For measuring the external diameters of screw-threads a pair of wide-pointed callipers is the correct tool to use. Vernier callipers and micrometer callipers are used when great accuracy is required. With these instruments it is an easy matter to take measurements as small as 1/1000th of an inch.

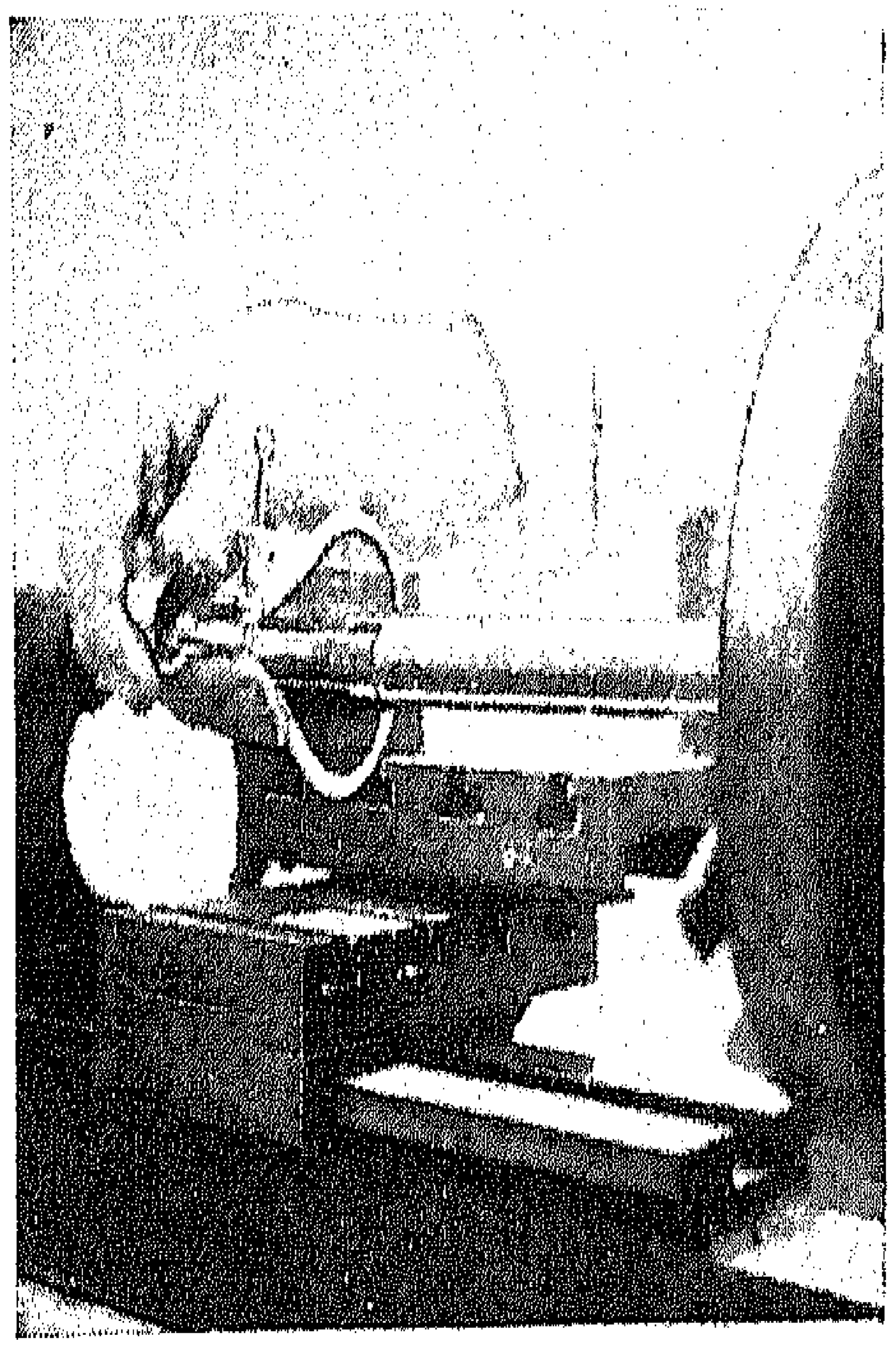


Fig. 10

Measuring.—The best way of explaining how measurements are made with external callipers, is to give a typical example. Assume that it is required to measure the diameter of a circular metal bar, suspended between the centres of a lathe, as shown in Fig. 10. First open the legs of the callipers (A, Fig. 9) so that the distance between the points is a fraction of an inch larger than the diameter of the work. Now, with the callipers held loosely at the joint between the thumb and forefinger, gently tap the bottom leg on the work. This will cause the legs to close a trifle. Place the callipers squarely across the bar. If the points just lightly touch at the top and bottom of the work, that is, slide over it without any pressure whatsoever, you may assume that the operation has been properly done. If, however, the callipers close too much at the first trial, repeat the operation until the desired result is obtained. The next step is to read off the measurement with the aid of a rule. Place the point of one leg against the end of the rule and read off the measurement where the point of the other leg coincides with the figure on the rule. This is shown in Fig. 11.

The important point to be observed when using callipers is that the points must only touch the work lightly, otherwise inaccurate measurements will result, owing to the natural spring of the tool. After some practice it is quite an easy matter to detect a difference in size as small as 1/1000th of an inch. Never use callipers on revolving work.

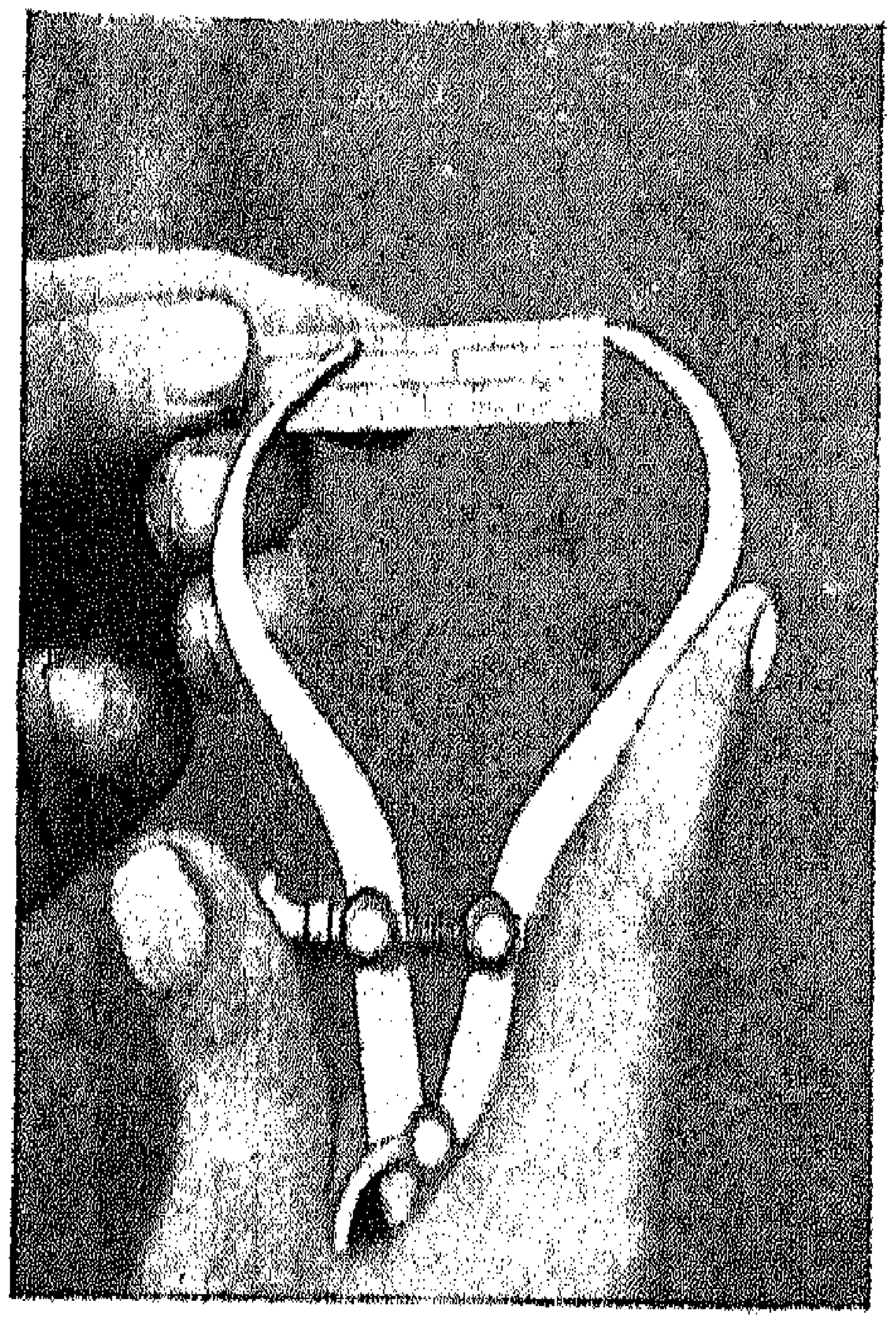


Fig. 11

To Use Inside Callipers, proceed in the manner indicated in Fig. 12. Adjust the callipers by gently tapping the leg—not the point—as previously explained. Insert the callipers into the hole to be measured, keeping the bottom point stationary and rocking the upper leg to and fro. The measurement is correct when the top point just touches the surface of the metal. Place a rule against a flat surface to keep one point of the tool level with the end of the rule, and read off the measurement, as illustrated in Fig. 13.

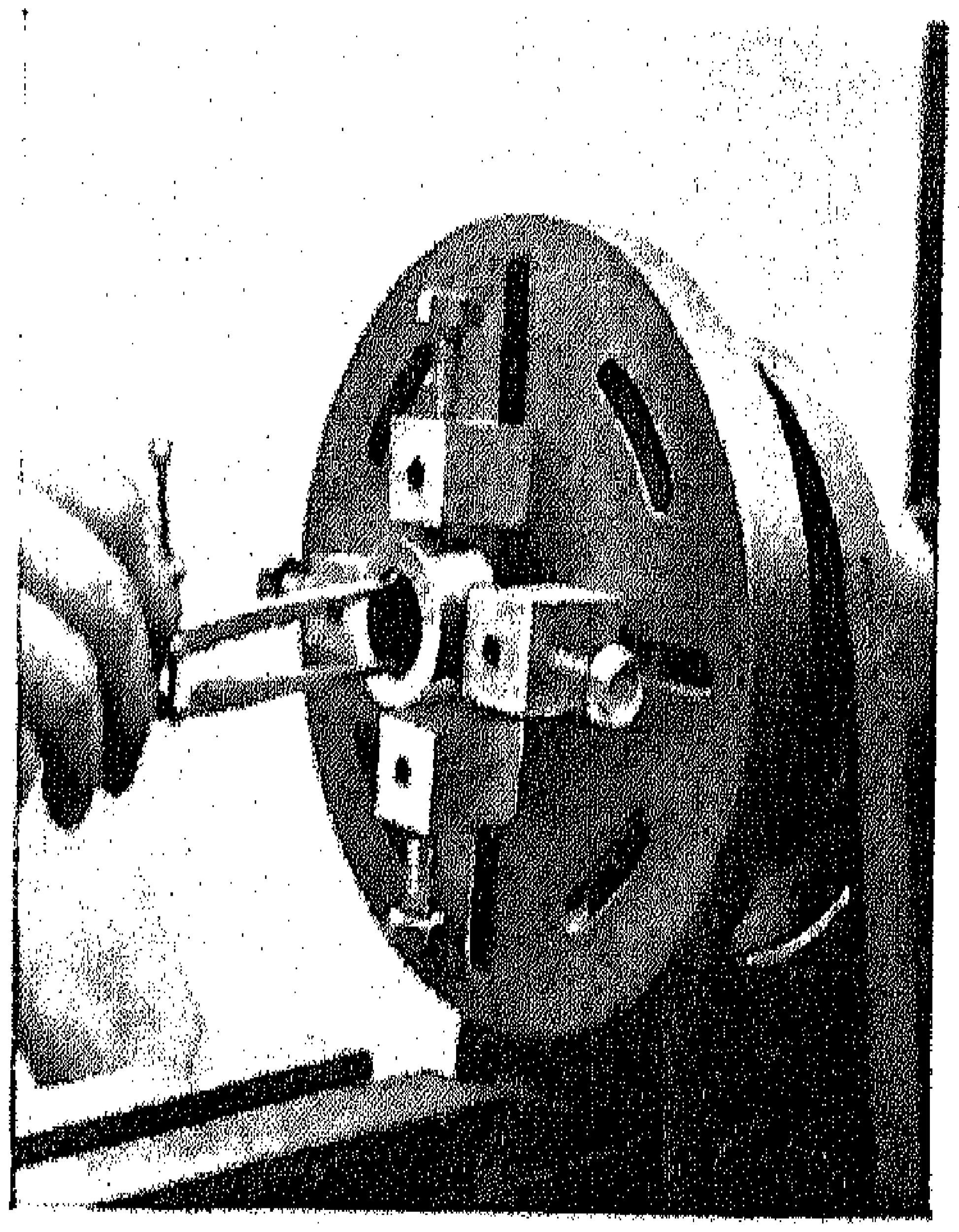


Fig. 12

The Depth-gauge.—A simple tool which can be made quite easily is the depth-gauge shown in the accompanying sketch. (Fig. 14.) With this it is possible to measure depths of holes and recesses. It consists of a mild-steel stock

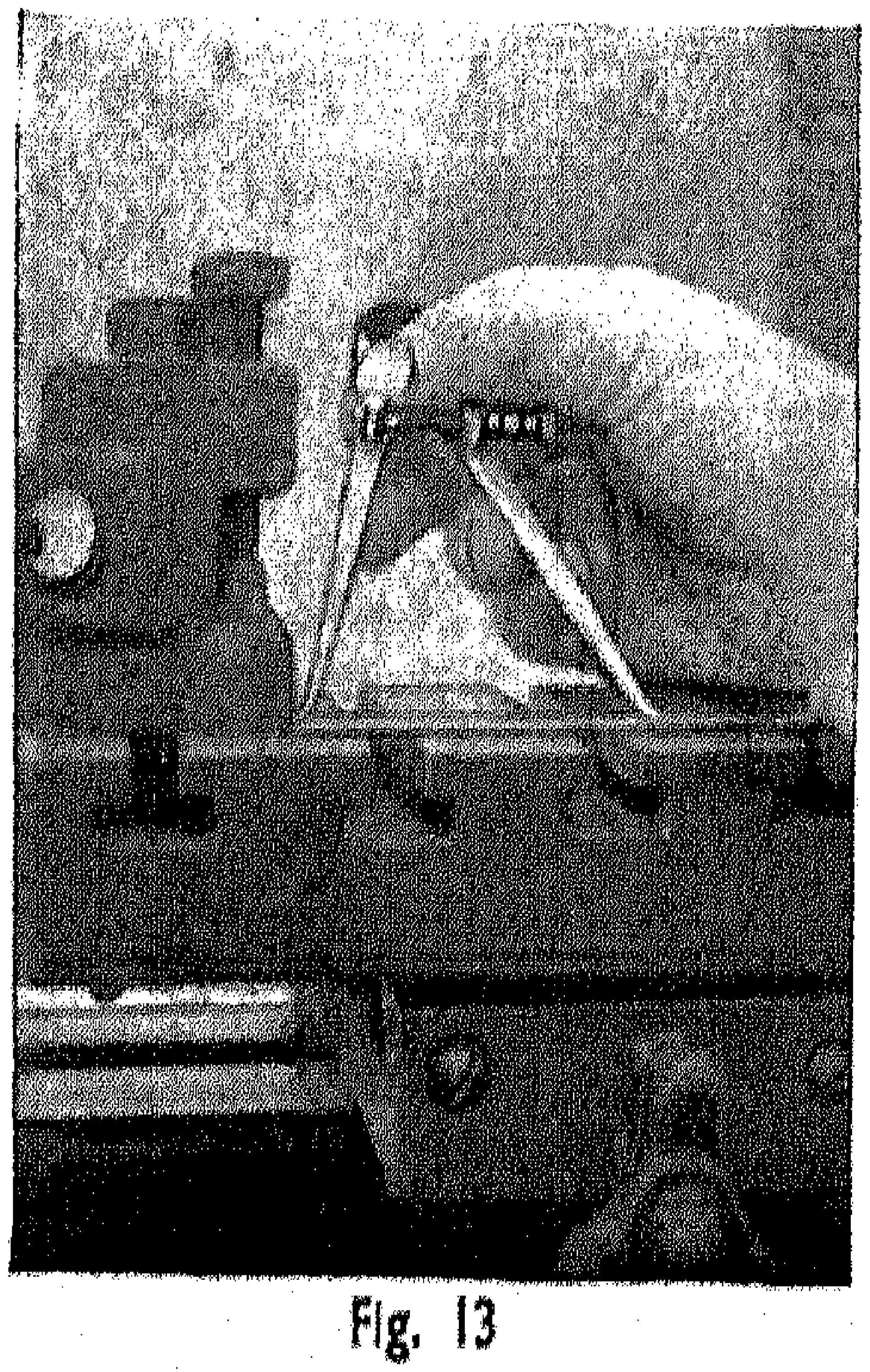


Fig. 13

drilled in the centre to take a $\frac{1}{8}$-in. spindle. The spindle is filed along its length to provide a narrow, flat surface. Another hole is made in the stock at right-angles to the spindle-hole in such a position that a portion of the hole passes through the spindle-hole. A small piece of steel of the same diameter is filed to produce a wedge-shaped surface which, when inserted into the aperture, locks the spindle.

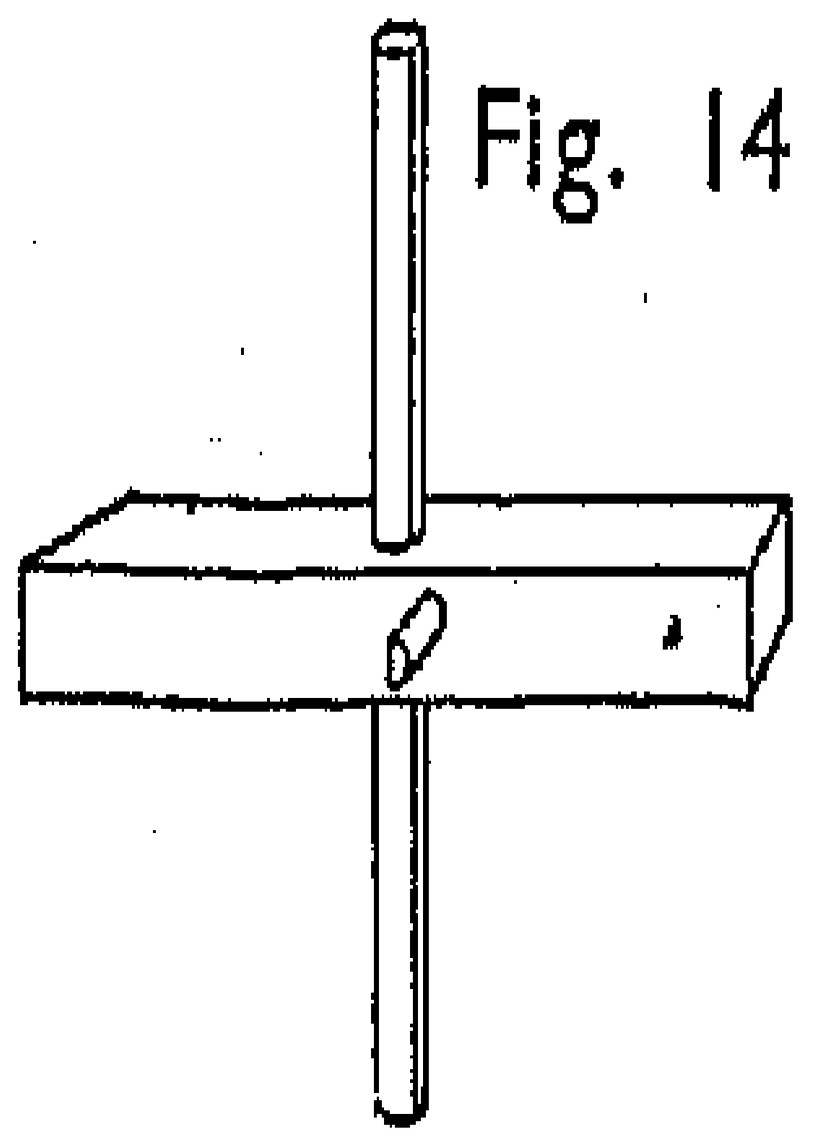


Fig. 14

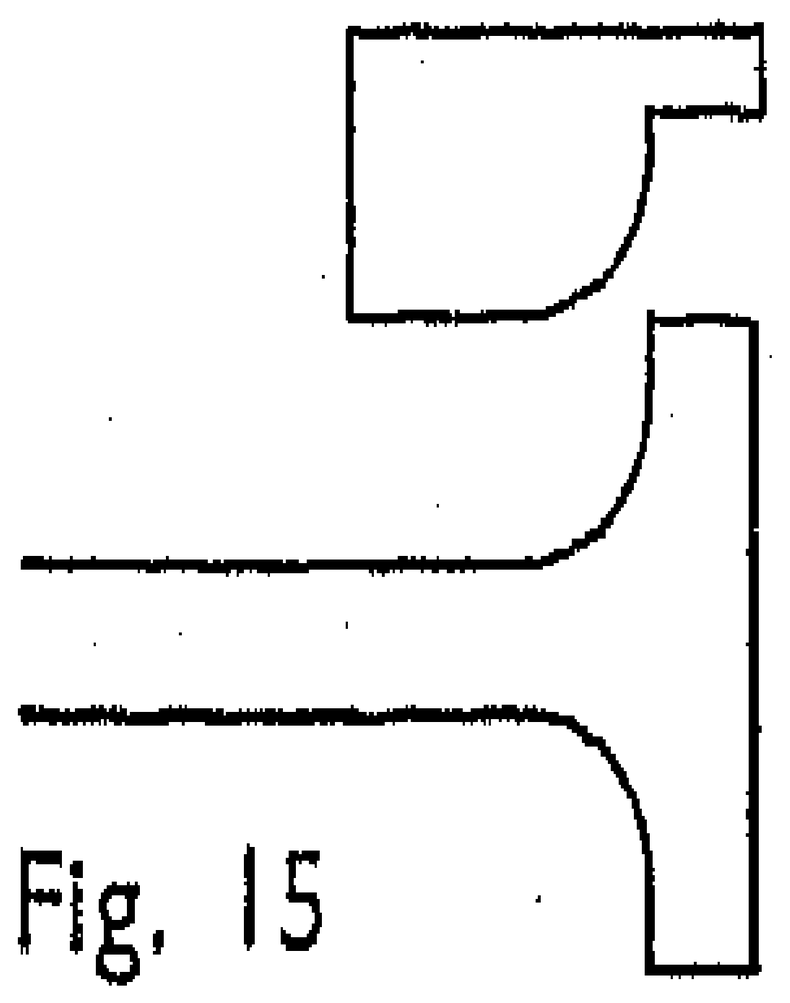


Fig. 15

Templates are useful yet simple devices used principally for gauging and testing the accuracy of curved work; two examples appear in Fig. 15. They can be made of thin sheet iron, or tinplate, or even of thin card, by first marking out the required shape and cutting to the marked lines, using either a pair of metal-shears or a pair of scissors, as the case may be.

Chucks.—We now come to the important subject of chucks and other devices for holding work in the lathe.

Although it is possible sometimes to do quite good work in the lathe with makeshift appliances ingeniously applied, it is far better to have the correct apparatus to hand when it is required, and so save a lot of valuable time.

As some chucks are expensive to buy, the best way to acquire them is to buy them separately, bearing in mind that the acquisition of good tools is a paying investment, and that they will give life-long service if properly treated and looked after.

The first indispensable item in the list is a driver-plate or catch-plate, used for driving such work as spindles, bars, etc., which are required to be turned between the centres of the lathe. Such a driver-plate is represented at A in Fig. 16. This accessory is sometimes supplied with the machine, and is quite a simple contrivance, consisting of nothing more than a flat plate fitted with a projecting stud which screws on to the mandrel nose. The stud engages with a "carrier" which is attached to the work to be driven.

An Independent-jaw Chuck is necessary for holding such work as heavy, irregular-shaped castings; an illustration of it appears at B. It should be large enough to take the largest work within the capabilities of the lathe. As its name suggests, the chuck is fitted with four jaws, each of which can be adjusted independently of the others, the adjustment being effected by turning the adjusting screws on the side of the chuck. This adjustment allows irregular-shaped work to be securely held in the jaws, and also allows holes to be bored in work where such holes are not central with the work. Reference to the drawing shows that the jaws are furnished with a series of steps which enable work of different diameters to be held. The jaws are also reversible to enable hollow work to be gripped from its internal surface.

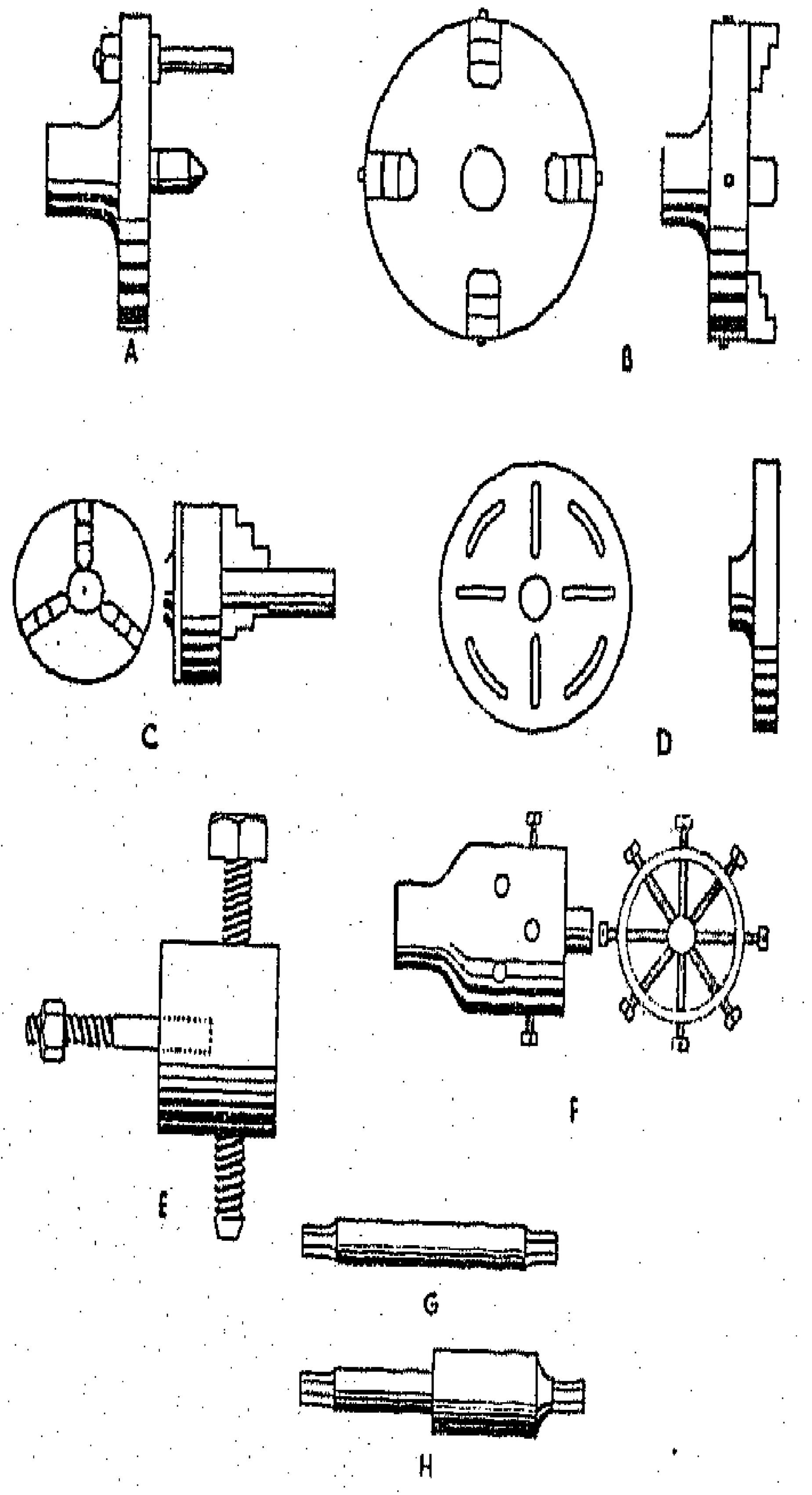


Fig. 16

Another type of chuck, with self-centering jaws, is shown at C. This form of chuck is usually provided with three jaws which all open or close at equal distances apart by the turn of a screw. This useful feature allows such work as rods, bars, small castings and drills to be held central. When acquiring a self-centering chuck it is advisable to choose one having two sets of jaws; one set for holding drills, rods, etc., and the other for holding castings and the like.

A Face-plate is a simple robust cast-iron plate having a dead true working surface with a series of slots and holes cast in it (as shown at D). The holes and slots enable bolts to be passed through them for fixing work to its surface.

"Dogs," furnished with adjustable screws, are obtainable or can be easily made. They are fixed to the face-plate and provide a good substitute for an independent jaw-chuck. These useful accessories are shown at E.

A Bell-chuck consists of a simple casting, usually having two sets of equally spaced set-screws fitted round the chuck (as shown at F). Such a chuck is useful for holding shafts, spindles and work of a similar nature.

A Plain Mandrel or "arbour," represented at G, is merely a round bar of metal used for mounting a piece of work for turning between centres which cannot be otherwise supported. This accessory consists of a bar of cast steel—although mild steel is often used with success—centred at the ends and turned to size. The two ends of the mandrel are usually turned to a smaller diameter than that of the main portion, and are provided with a "flat" or a square to enable the working end of the screw of the carrier to secure a good grip. The centre portion upon which the work is mounted is turned slightly taper so that when it is driven on the work it forms a wedge and grips the work. A set of double mandrels (as illustrated at H) are useful appliances to have, and as they are quite simple to make, the craftsman should make a set for himself. Mandrels should be stored away in a box, and great care should be taken to see that they are not allowed to knock up against each other, otherwise their accuracy is likely to be seriously impaired. When fitting a mandrel into a piece of work, place the work face downwards on the open jaws of a vice and insert the mandrel after having applied a spot or two of oil to prevent binding. Place a piece of lead, brass or hardwood on the top end and drive the mandrel home, taking care not to force it too much.

Centering.—Before a bar of metal can be turned between the centres of a lathe, each end of the work must have accurately-centred and correctly-shaped centre-holes to suspend and to drive the work between the lathe centres. Before these holes are drilled, however, it is necessary to prepare the ends of the metal and correctly locate and mark out the positions where these holes are to be.

For the purpose of explaining these matters it is assumed that a piece of round material is required to be turned down to a certain size. The first thing to do, after having sawn off a piece of bar of the desired length, is to place it between the jaws of a vice and file the ends flat and square. Next, get a piece of chalk and rub it over the surfaces so prepared to enable the lines which are to be marked to be easily seen. Take a pair of odd-leg callipers, open the legs so that the distance between the points is just under half the diameter of the work. Place the point of the plain leg of the callipers in contact with the edge of the material and scribe a mark near the centre of the chalked surface. Repeat this operation at four equidistant intervals round the circumference of the bar, as shown clearly in Fig. 17. Centre-pop the middle of the space made by the lines, using a centre-punch and hammer for the purpose. Remove the bar from the vice and repeat the process at the other end. Another way of centering a piece of round rod is by the use of a simple device known as a centering square (shown in Fig. 18). It consists of a metal square having a blade fixed on it so that one of its edges exactly divides the right-angle formed by the two sides of the square into two equal angles of 45°. To locate a centre, all that is necessary is to place the square over the end of the work and draw a series of lines across the work as indicated in the drawing. The centre is obviously where the lines cut one another.

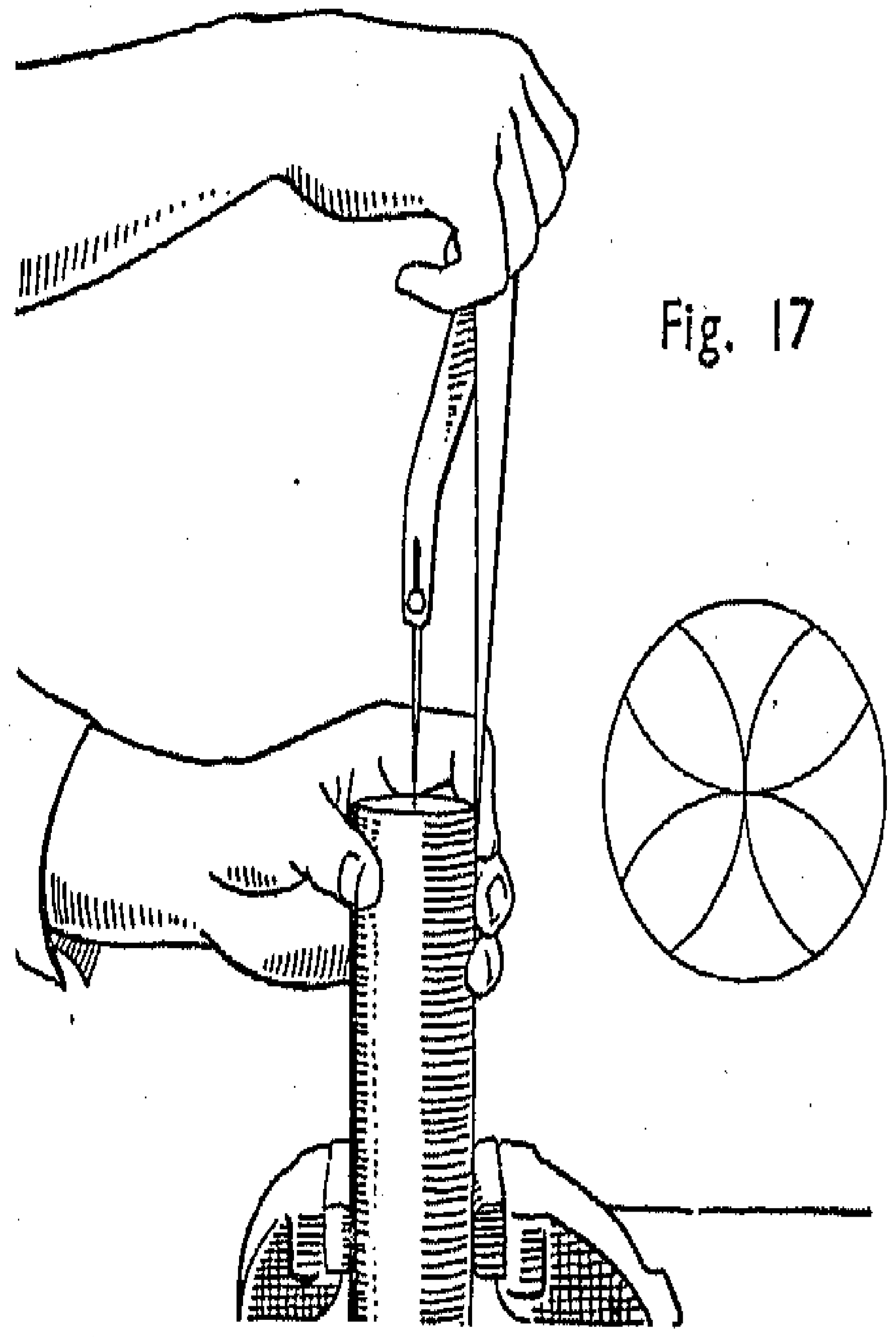


Fig. 17

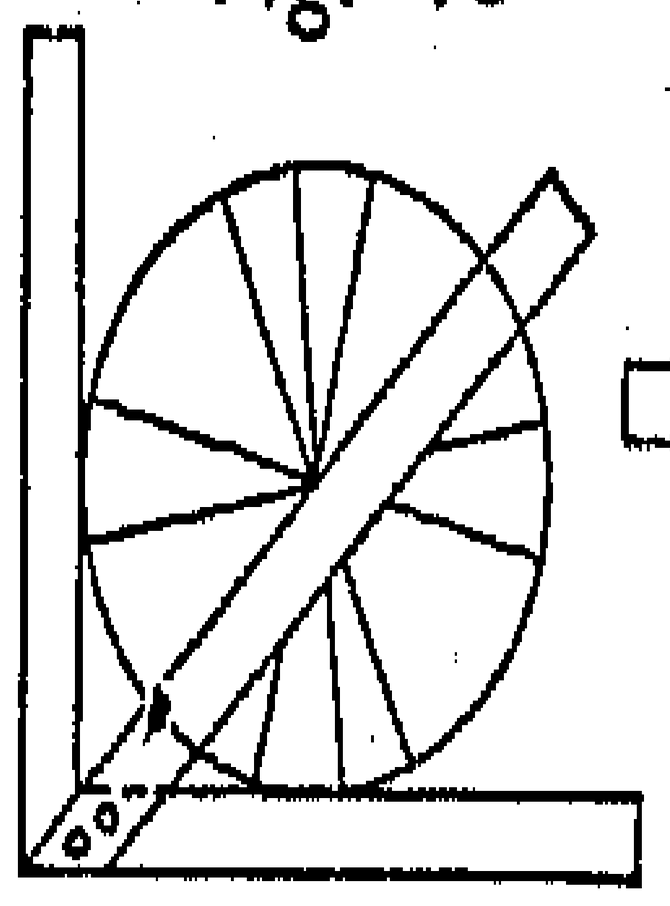


Fig. 18

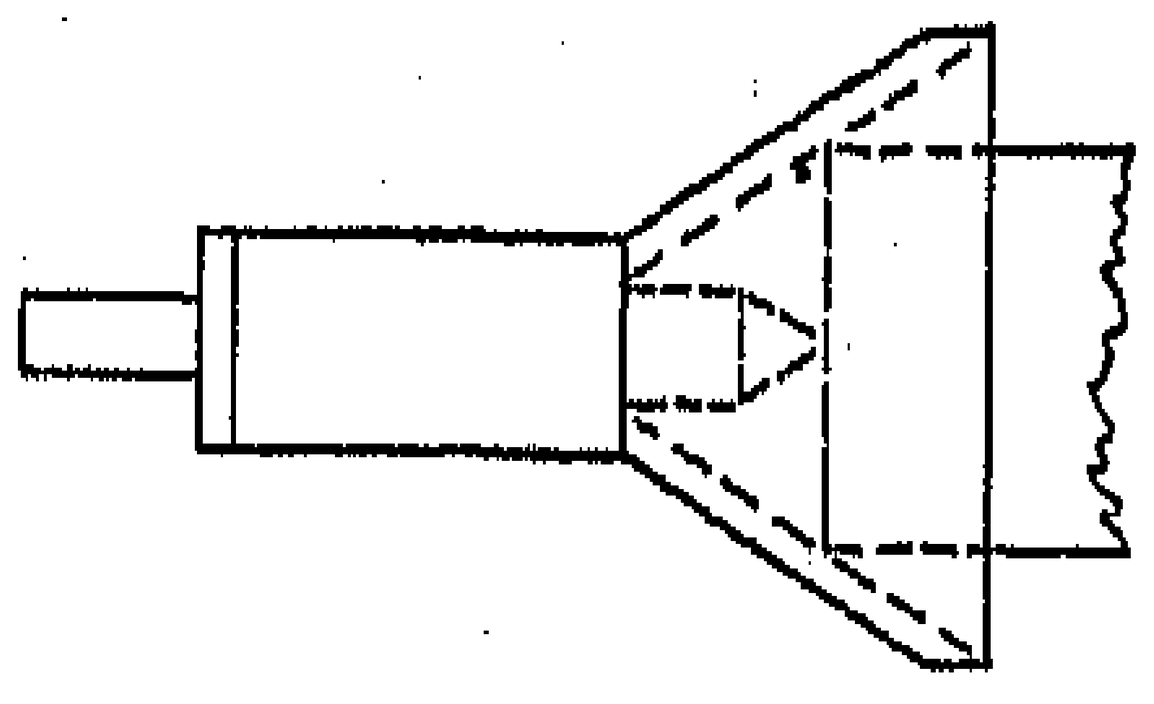


Fig. 19

The Bell Centre-punch.—Another tool for automatically centering round metal rods is the bell centre-punch, illustrated in Fig. 19. The use of this simple device obviates the necessity of marking out the centres and thus saves a lot of time. The main point to be observed when using this tool is that the ends of the metal to be centred must be perfectly square. A glance at the drawing will show that this tool consists essentially of a cone-shaped holder the top of which is accurately bored to take a good-fitting centre-punch. To use the tool all that is required is to place the cup squarely over the work and give the punch a smart tap with a hammer.

Fig. 20 shows another method of centering round bars where a surface-gauge—or, as it is sometimes called, a scribing-block—is used in conjunction with a pair of V-blocks. When the ends of the work have been prepared as previously described, place the V-blocks on a perfectly flat surface such as the lathe-bed, or a piece of plate glass—which, it may be mentioned, comes in very handy for providing a flat surface for testing all kinds of metal-work—and lay the bar between the grooves in the blocks, as shown in the illustration. Set the point of the scriber of the surface-gauge approximately level with the centre of the work, and then mark a series of horizontal lines on each end of the bar, which should have been previously chalked. This is accomplished as follows. Hold the foot of the surface-gauge with the right hand and steady the work with the left, if necessary. Draw the tool along in such a direction that the point of the scriber marks the work. Next, revolve the bar a quarter of a turn and scribe another line and repeat this operation until a number of lines is produced as shown in the illustration. Centre-pop the work where these intersect.

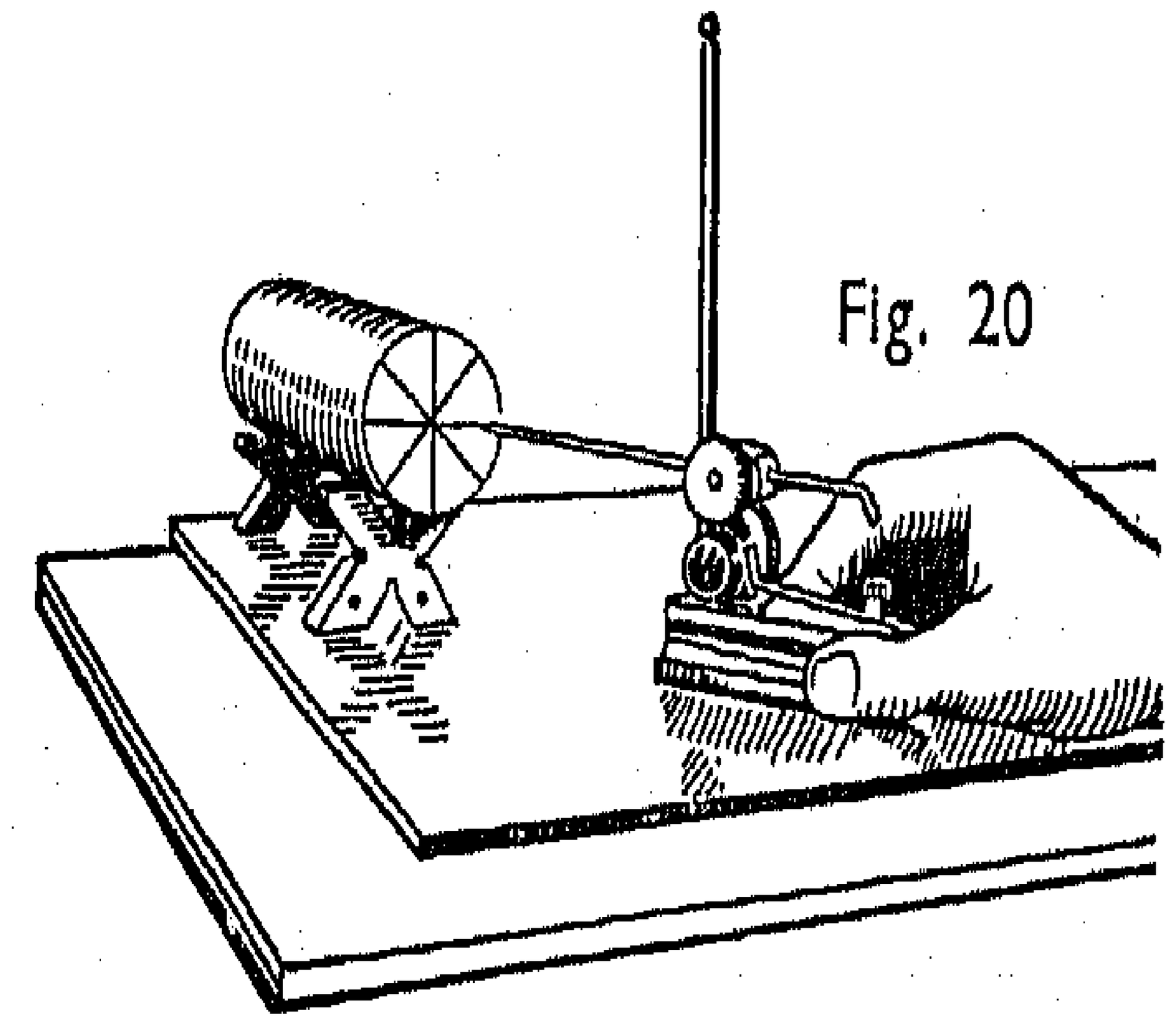


Fig. 20

Testing for Accuracy.—Suspend the work between the centres of the lathe using the centre-pops as centre holes, and spin the work round by the fingers. If the work wobbles, it is out of true. Hold a piece of chalk near the end of the bar in such a position that when the work is spun round, the side farthest from the centre will touch the chalk and thus mark the bar. Remove the work from the lathe, fix it end-up in the vice and draw over the defective centre-pop towards the chalk-mark. Replace in the lathe and repeat the operation until satisfactory results are obtained.

Having satisfied yourself that the centre-marks are as they should be, the next thing to do is to drill the centre-holes. These centre-holes are very important, for not only must they be shaped to correspond with the angle of the lathe centres—which is usually an angle of 60° in small lathes—but they must also be sufficiently deep to enable the points of the lathe centres to clear the work. To make these holes, place the work in the vice—end-up, of course—and with a $\frac{1}{16}$-in. drill make a hole about $\frac{3}{16}$ in. deep. This hole will be deep enough for the lathe centre to clear the bottom. Now, with a larger drill having an angle of 60°, countersink the hole as shown in Fig. 21, which completes the job.

The Slocombe Drill.—The Slocombe drill is a drill and countersink combined. When buying one of these drills do not forget to mention the angle of the countersink, which must, as already stated, correspond with the angle of the lathe-centres.

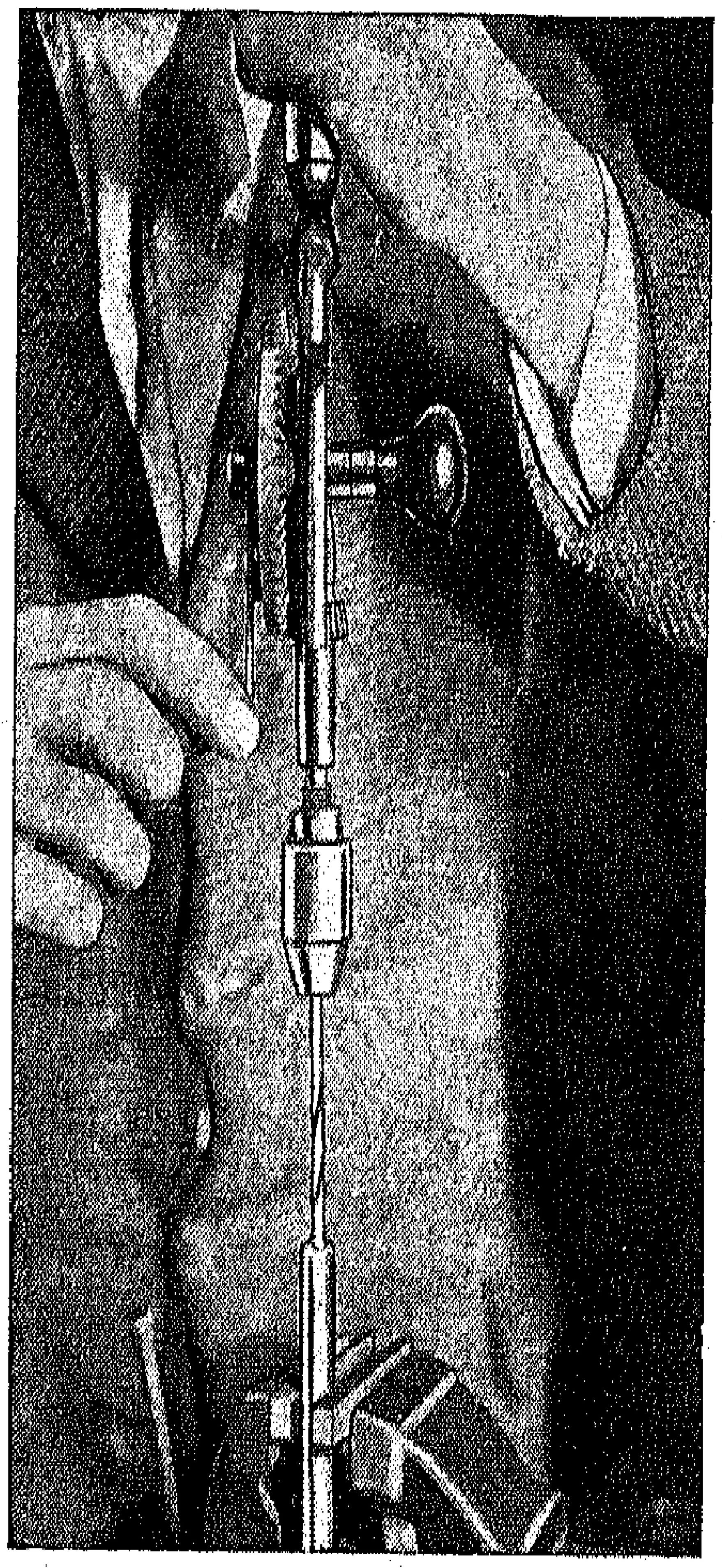


Fig. 21

The usual method of applying the centering drill is by fixing the drill into a small chuck held in the back headstock spindle. The drill is then fed up to the work in a self-centering chuck. An alternative method is to place the work against the back centre and feed it up to the revolving drill held in a self-centering chuck.

These two simple methods will

no doubt meet the general requirements for ordinary work done on small lathes.

Plain Turning.—The next step in lathe work brings us to the actual process of plain turning, and in order to describe the methods involved, step by step, in a simple manner, a typical example of such work will be given.

For this example it will be assumed that a mild-steel shaft, as shown by the dotted outline at A in Fig 22, is required for a certain piece of mechanism. The finished size of the job is to be 5 in. long; its largest diameter ⅞ in., and its smaller one ⅝ in.

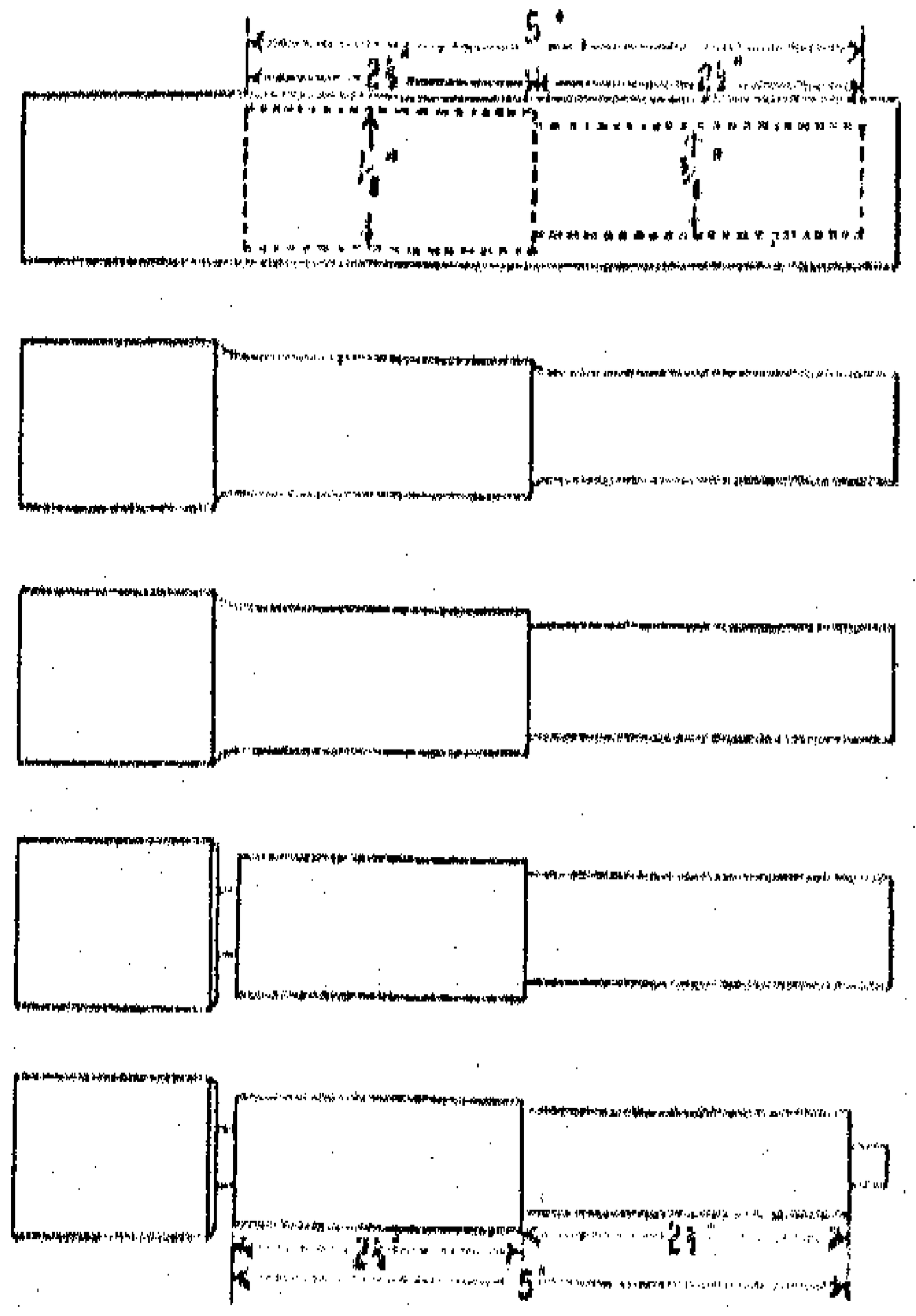


Fig. 22

Cut a piece of mild steel 7 in. long from a piece of 1-in. diameter circular bar. The additional length included will give sufficient metal at each end over the finished size for the purpose of fitting the carrier, etc., and allow the slide-rest to be operated in a convenient manner. File the ends perfectly square, drill the centre-holes as previously explained, and fix a suitable carrier over one end. Fix the work between the centres of the lathe after having put a spot of oil in the centre-hole where it is to revolve on the fixed centre. Test the work to see that it revolves easily and without any rock when turned with the fingers. Fix a suitable front turning-tool in the tool-post of the slide-rest, taking care to see that it is at the correct height. Start up the lathe so that it revolves in the right direction, that is, of course, towards the operator. Adjust the handle of the bottom slide so that the tool will make a cut deep enough to reduce the diameter of the work to about $\frac{1}{32}$ in. or so larger than the finished size is to be. The small amount left on will allow a light cut to be taken for finishing. Now turn the top-slide handle and traverse the tool along the length of the work until within a little under an inch of the end. Withdraw the tool a trifle by turning the bottom-slide handle whilst the work is still revolving. Make sure you turn this the right way. Bring the tool back to its original position and stop the lathe. With a rule set along the work, mark the position of the shoulder. Light centre-punch marks will come in handy for this. Start the lathe again and take another cut along the work until the centre-pop mark, indicating the position of the shoulder, is reached; withdraw the tool and repeat the operation until this part is about $\frac{1}{32}$ in. oversize. The work will now appear as in the illustration at B, and is known as "roughing out."

The finishing cuts may now be taken. If you have not a separate tool for this, see that the one being used is in perfect order. Start with the large diameter part by taking a light cut, and reduce its diameter to its exact finished size, namely, ⅞ in. diameter.

Lubricating the Cutting-edge.—To obtain a good finish on mild steel it is necessary to lubricate well the cutting-edge of the tool with soap and water

It is also wise to lubricate the tool during the roughing-out process.

Having completed the main portion of the work, remove the front turning-tool from the tool-post and fix a knife-tool in its place to remove the surplus metal left in the shoulder. The work at this stage is shown at C.

Using the Parting-tool.—Measure the exact distance between the shoulder and the ends, which in this case is 2½ in. The position marked at the carrier end of the work gives the position where the right-hand cutting-edge of the parting-tool enters the metal for parting off.

Set the tool squarely in the post and take a cut (D), but do not make this too deep at present as the opposite end must now receive attention.

Take the parting-tool out and substitute the knife-tool again and face the right-hand end to size, taking care to leave a small portion round the centre-hole, as illustrated at E, as the work is not yet complete. With the parting-tool carefully set in position complete the cut previously started at the carrier end until there is just sufficient metal left to support the work. Now, with the work still revolving, just touch the edges of the shoulder and the ends of the spindle with a fine file to remove the sharp edges. This last operation should be done where all sharp edges are concerned, for it often prevents the fingers from being cut. Polish the work with a piece of very fine emery-cloth and oil. Take the work out of the lathe and remove the unwanted portions with a hacksaw, finally smoothing down the rough surfaces left by the saw with a file.

In some jobs it is good practice to leave the centre-holes in the work so that it can be suspended between centres at any future time. This would apply, for example, in the case of an exhaust valve for a gas engine, which sometimes requires re-turning on the valve face.

Occasionally it may be necessary to use a file upon the revolving work to impart a good finish, in which case a sheet of paper spread under the work will prevent the filings from penetrating the various parts of the machine.

When turning a shaft or spindle to fit a hole, turn the work down to about 1/1000-in. oversize, and complete to the exact size with a fine-toothed file, finishing the surface with fine emery-cloth and oil.

The Steady.—When a long thin bar or spindle is to be turned, a "steady" or stay should be used to keep the work from bending and "whipping" when under the pressure of the cutting-tool. Failure to take this precaution will almost certainly lead to inaccurate turning, even if the work remains upon the lathe-centres. Such a steady can usually be obtained from the makers of the lathe. A common type of fixed stay consists of a casting, the foot of which is bolted down to the lathe bed. The top half of the upper portion of the stay is made to open to take the work, and has three sliding pieces which can be adjusted by means of the bolts to suit various sizes of shafts.

This type of steady is only used when the slide-rest is used for turning a short length of a long piece of work. When the whole length of the shaft is to be turned, a travelling steady fixed to the saddle is used. With this type of steady the work is supported rigidly, following the tool, which not only enables the self-acting motion to be used, but also allows comparatively deep cuts to be made. Care must be exercised in fitting a steady, and the bearing surfaces between the steady and the revolving work must be well lubricated.

Turning Tapered Work.—The two simplest ways are either to set the tail-stock over, or to use the compound slide-rest. In the former method the dead centre A and the live centre B are thrown out of line, as shown in Fig. 23. The amount by which the back centre is moved across the lathe is determined by the amount of taper required. To quote an example, suppose it is required to turn a bar 12 in. long by 2 in. diameter at the large end and 1 in. diameter at the other. Now the total taper is 1 in. to the foot, therefore it will be necessary to set over the tailstock ½ in. because the taper on one side of the work is only ½ in. This method of taper turning is limited in practice to work where only a small degree of taper is desired, as it will be readily understood that neither of the centres really fit the centre-holes.

If a large degree of taper is wanted, the compound slide-rest must be brought into operation. The top-slide carrying the tool-post is swivelled round to the proper angle to produce the desired taper, which means that the slope of the front of the top-slide in relation to the axis of the work should exactly correspond with the required taper. Fig. 24 shows how this method of setting the slide-rest is applied. For the purpose of illustration, suppose it is desired to taper turn a piece of metal from 1 in. at A to ¾ in. at B. First turn the end at B down to ¾ in. diameter, and also turn the work at A to 1 in. Next, swing the top-slide round to approximately what seems to be the correct angle. Bring the point of the tool opposite A and measure a distance of, say, ½ in. from the surface of the work to the point of the tool D. Move the tool along by turning the handle until the point of the tool is opposite C. If these distances so measured are both equal, then it follows that the angle of the top-slide is correct. One of the most important points to be observed when turning tapers is to see that the cutting-edge of the tool is set exactly level with the lathe centres.

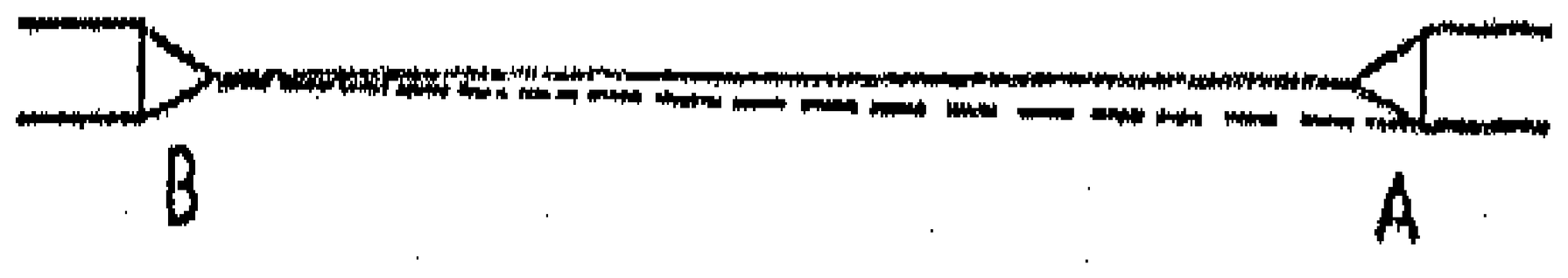


Fig. 23

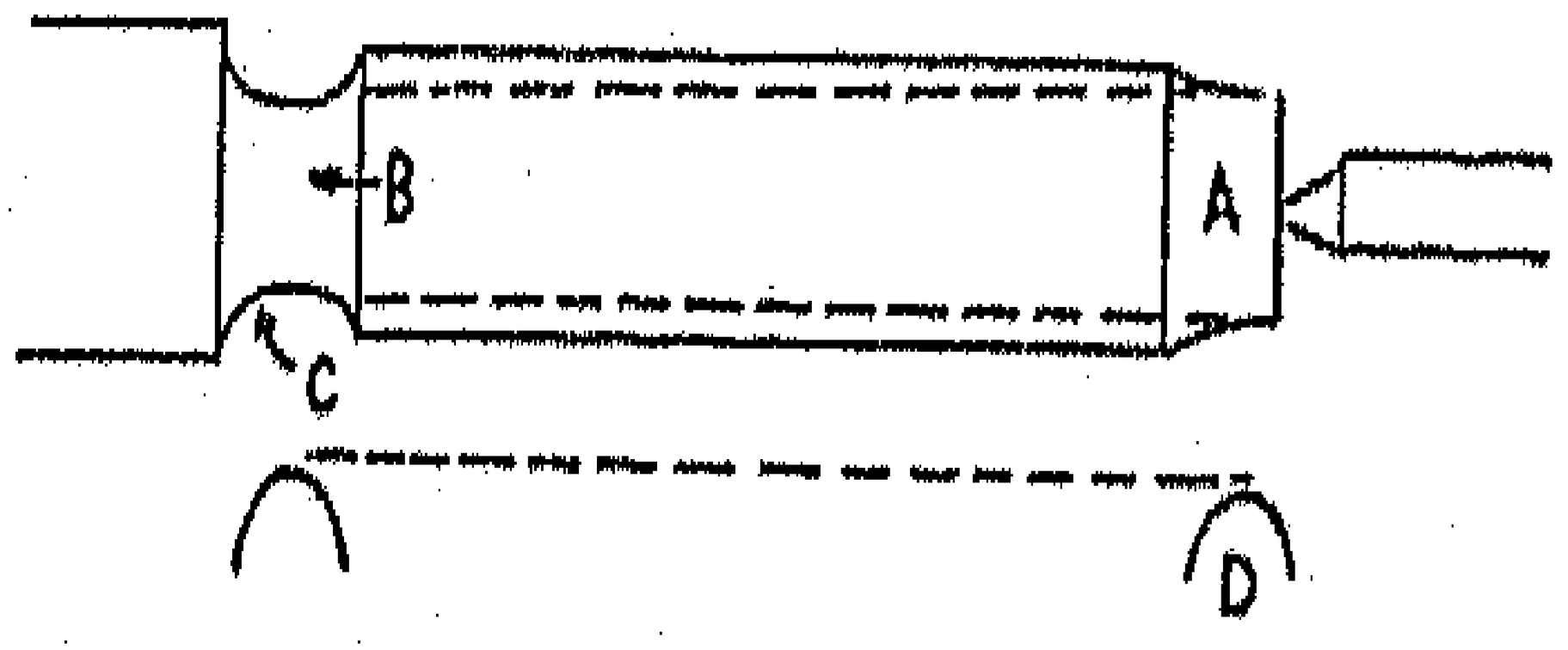


Fig. 24

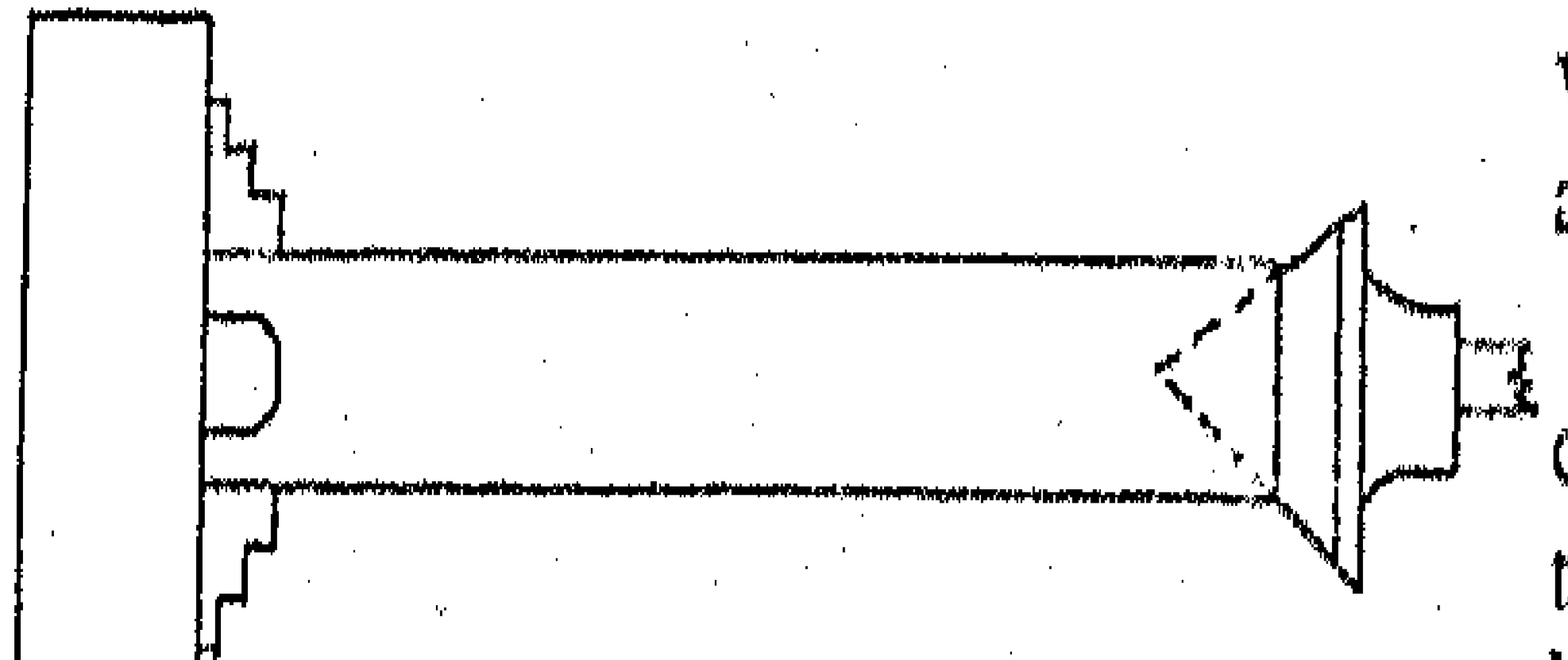


Fig. 25

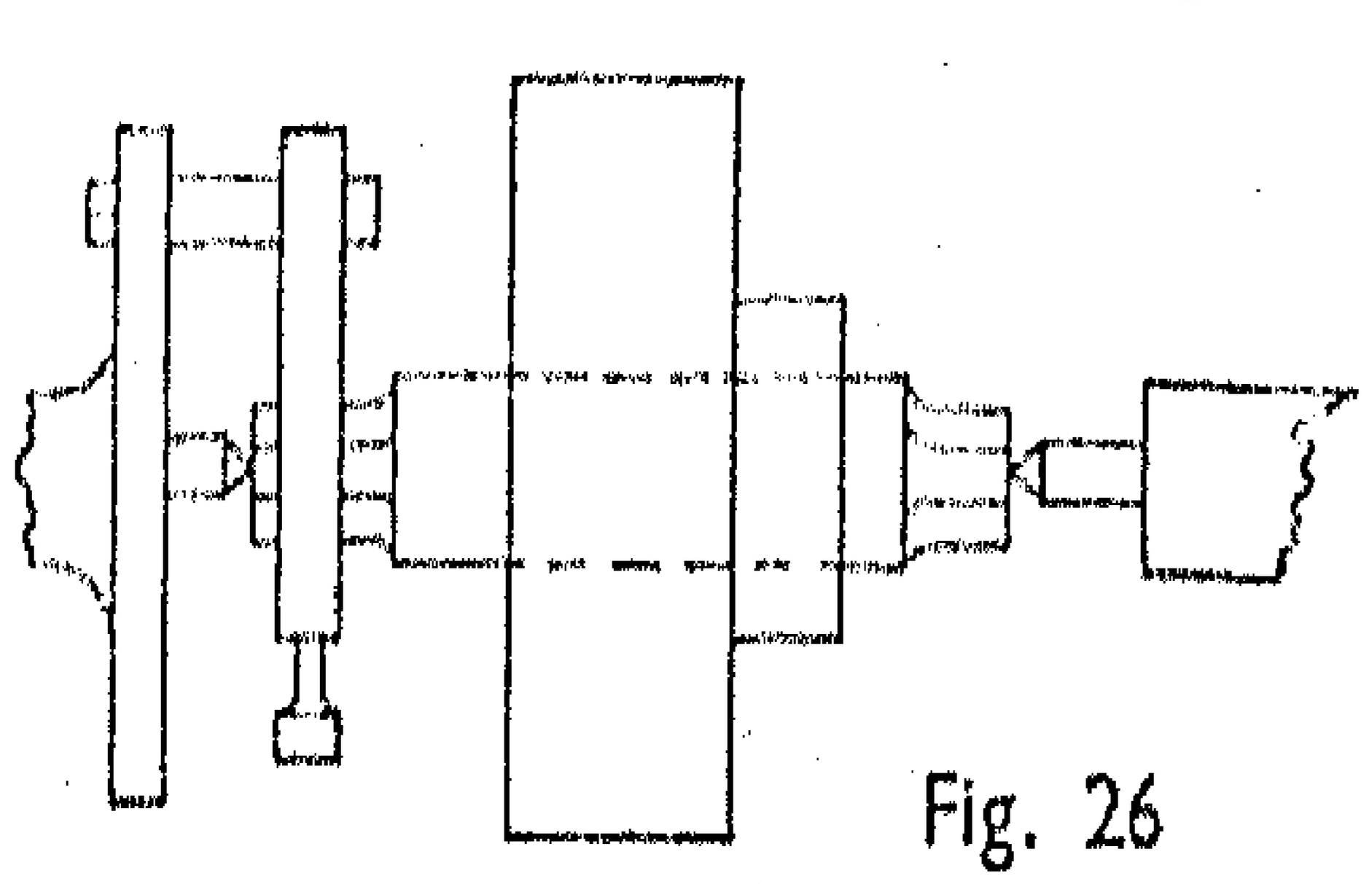


Fig. 26

Turning Hollow Objects.—Fig. 25 shows a common method of supporting hollow objects for turning. The tube is fixed in a jaw chuck and the other end is supported by a large cone-shaped centre. The cone revolves on a centre-pin which fits into the tapered hole in the loose headstock barrel. When such a centre is not available, the difficulty may be got over by inserting a piece of hard wood to fit tightly in the end of the work and centering it in the usual way.

Fig. 26 shows how a pulley-wheel casting is turned between centres. Here, the centre-hole of the wheel would first be bored and then it would be mounted upon a short mandrel. The work is driven by the catch-pin of the driver plate, catching against the carrier in the usual manner. The use of mandrels for turning work between centres is not limited to circular objects, for in a great many cases it is convenient to turn irregular-shaped objects in this manner. When this is resorted to, be careful to see that a weight is fixed on the driver-plate to counteract the weight of the work, which may be out of balance. If this precaution is not carried out it may cause the work and tool to chatter.

Although a great number of turning jobs can be successfully carried out by either suspending the work directly between the lathe centres or by mounting the work on mandrels, there are numerous jobs which cannot be conveniently turned by these methods. For turning short work and such work as boring and drilling in the lathe, chucks and face-plates are used. As to what type of chuck or whether a face-plate is used naturally depends upon the shape of the work and the operation to be performed on it.

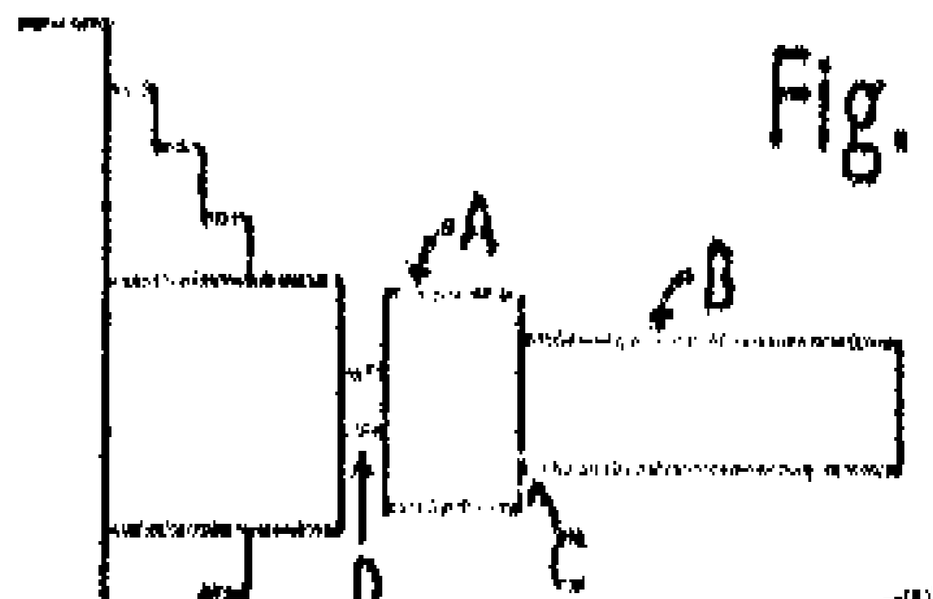


Fig. 27

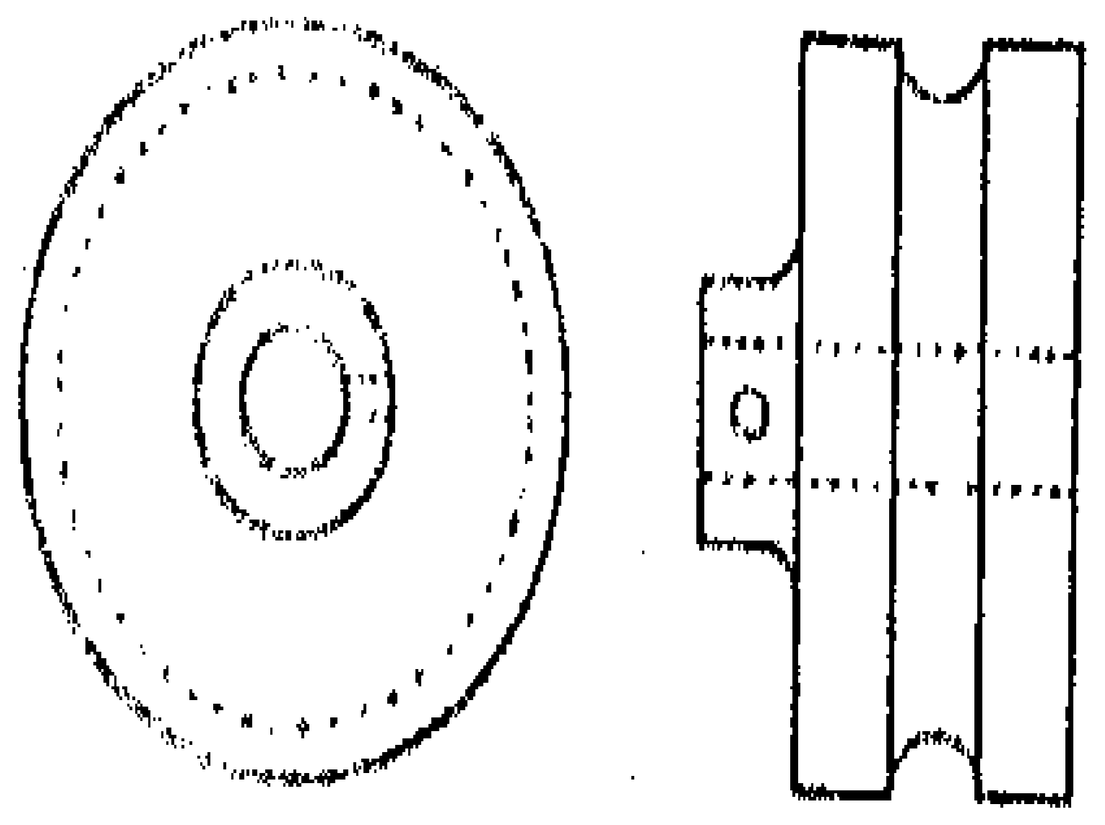


Fig. 28

A typical example of the use of a self-centring chuck, where a piece of round mild steel is to be formed into a special bolt, for a certain purpose, is shown diagrammatically in Fig. 27. The overall length of the bolt is to be 1½ in.; the diameter of the head is to be $\frac{7}{16}$ in. and its length ⅜ in.; the shank ¼ in. diameter and 1⅛ in. in length, and threaded with a ¼-in. Whitworth thread.

If the lathe has a fixed headstock, fitted with a hollow mandrel, a convenient length of ½-in. bar can be inserted into the tube, allowing 2 in. of the metal to project beyond the jaws of the chuck. If, however, the lathe is not so fitted, then a piece of the rod, about 3 in. long, should be cut off the bar, the extra length being necessary for holding-purposes.

The subsequent operations are then carried out in the following way: first, turn the head—which is the largest diameter—to size, as shown at A. Then follow with the shank, as at B. Next, form the shoulder C, finally parting off the pin, as shown at D. The screw-thread is then cut in the shank with a suitable hand-operated die, or, if the thread is to be cut in the lathe, the screw-cutting operation would be done before using the parting-off tool.

Turning a Small Grooved Pulley.—The following is the order of operations, as illustrated in Fig. 28.

A piece of solid mild-steel bar is inserted between the jaws of a self-centring chuck, and the largest diameter forming the top of the pulley is roughed out first. This is followed by roughing out the boss. The next process consists in drilling the hole for the shaft, and, when this is completed, the groove is roughly turned to shape. The work is then parted off and mounted upon a mandrel in order to take a light finishing cut all over. The job is complete when it has been polished with emery-cloth and oil, and a hole drilled and tapped in the boss to receive a fixing-screw.

Turning Irregular-shaped Objects where the use of a self-centring chuck is impracticable:

Fig. 29 shows an irregular-shaped piece of work in the form of a flange and guide inserted between the jaws of an independent-jaw chuck. It may here be stated that a certain amount of skill and practice is required in setting work of this description squarely and centrally in position before any operation upon it can be successfully carried out. When the work has been roughly set in position, start up the lathe, and if the work is out of centre, it will wobble when rotated. Hold a piece of chalk close to the work as it revolves, and where the work is marked, it indicates that part of the work which is set too high, or out of centre. Correct this error by adjusting the jaws and, if necessary, repeat the process until the work is revolving centrally and squarely.

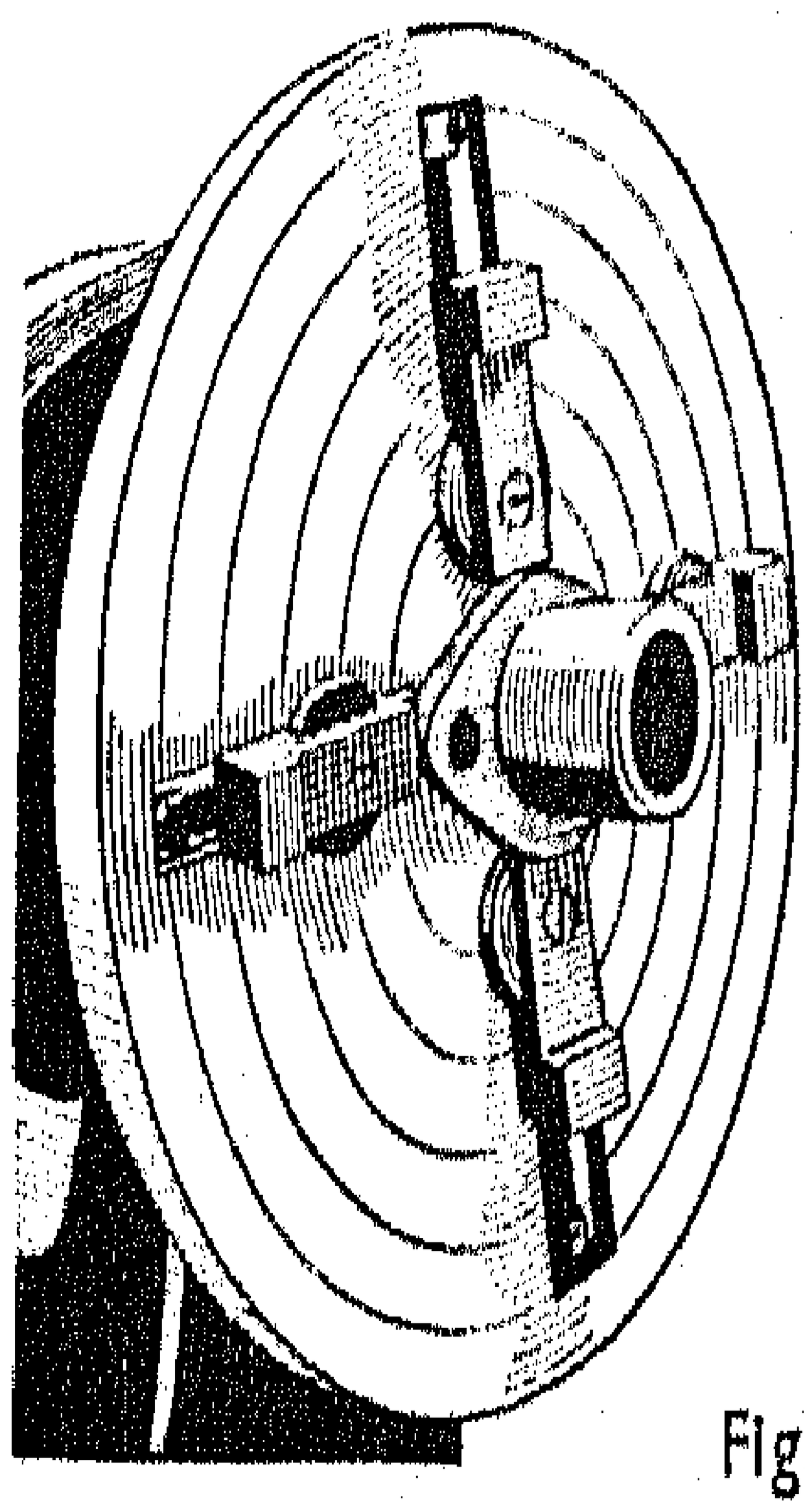


Fig. 29

Sometimes it is necessary to hold a piece of work exactly true in a chuck or on a face-plate, as, for instance, when a hole has to be bored out to a marked line. In such cases a scribing-block placed on the lathe-bed, and used in the manner indicated in Fig. 30A, is a convenient method of testing the accuracy of the chucking or mounting. As an alternative, a scriber can be fitted in the top slide of the slide-rest and the work adjusted so that the scriber just touches the line all round, as shown in Fig. 30B.

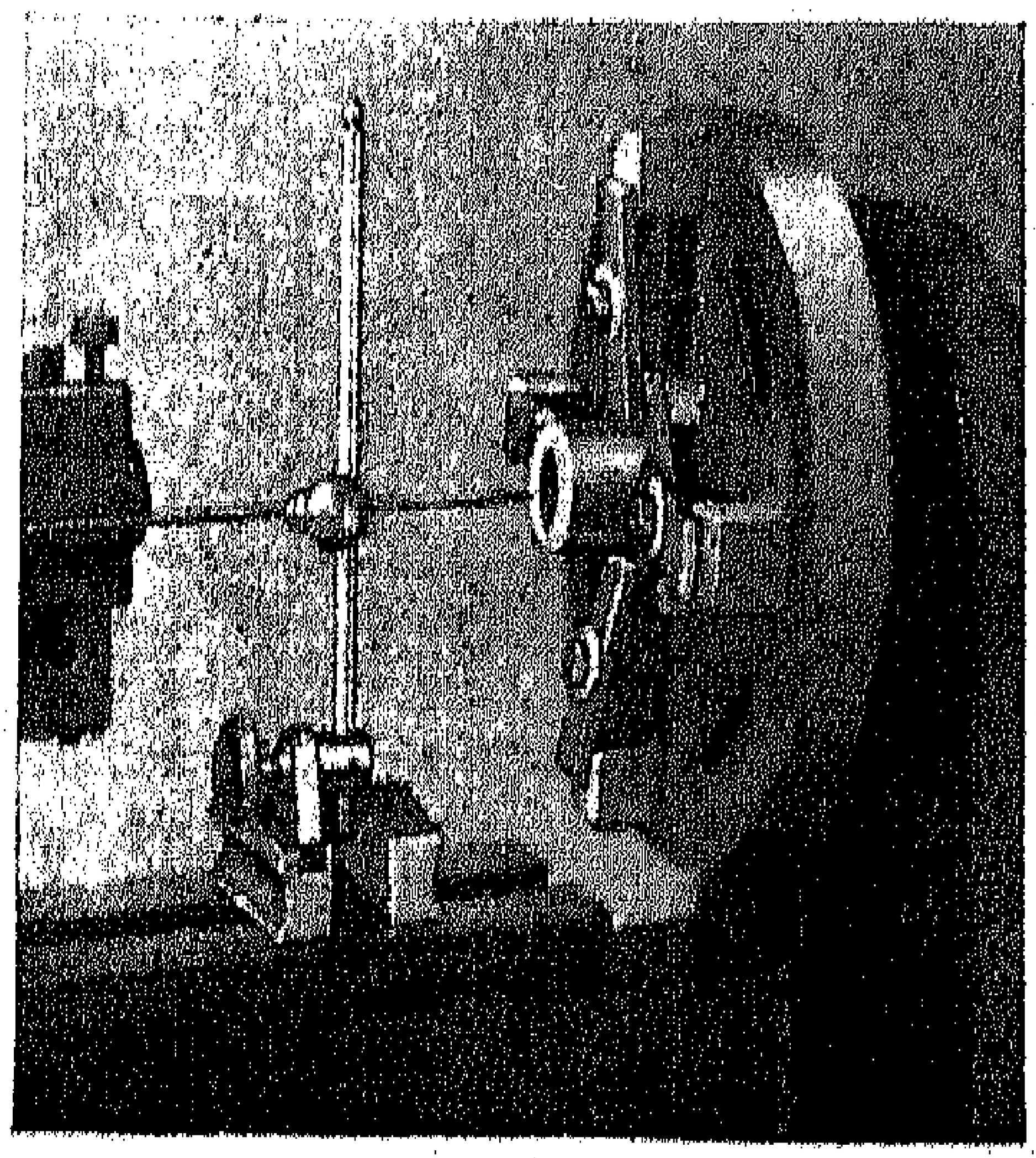


Fig. 30A

The usual way of fixing work to a face-plate is by the use of metal clamps bolted through the slots or holes in the plate. Fig. 31 shows a piece of work set up on the face-plate ready for boring. It will be observed that one end of each clamp rests upon the work while the opposite ends are supported by hardwood blocks or packing-pieces.

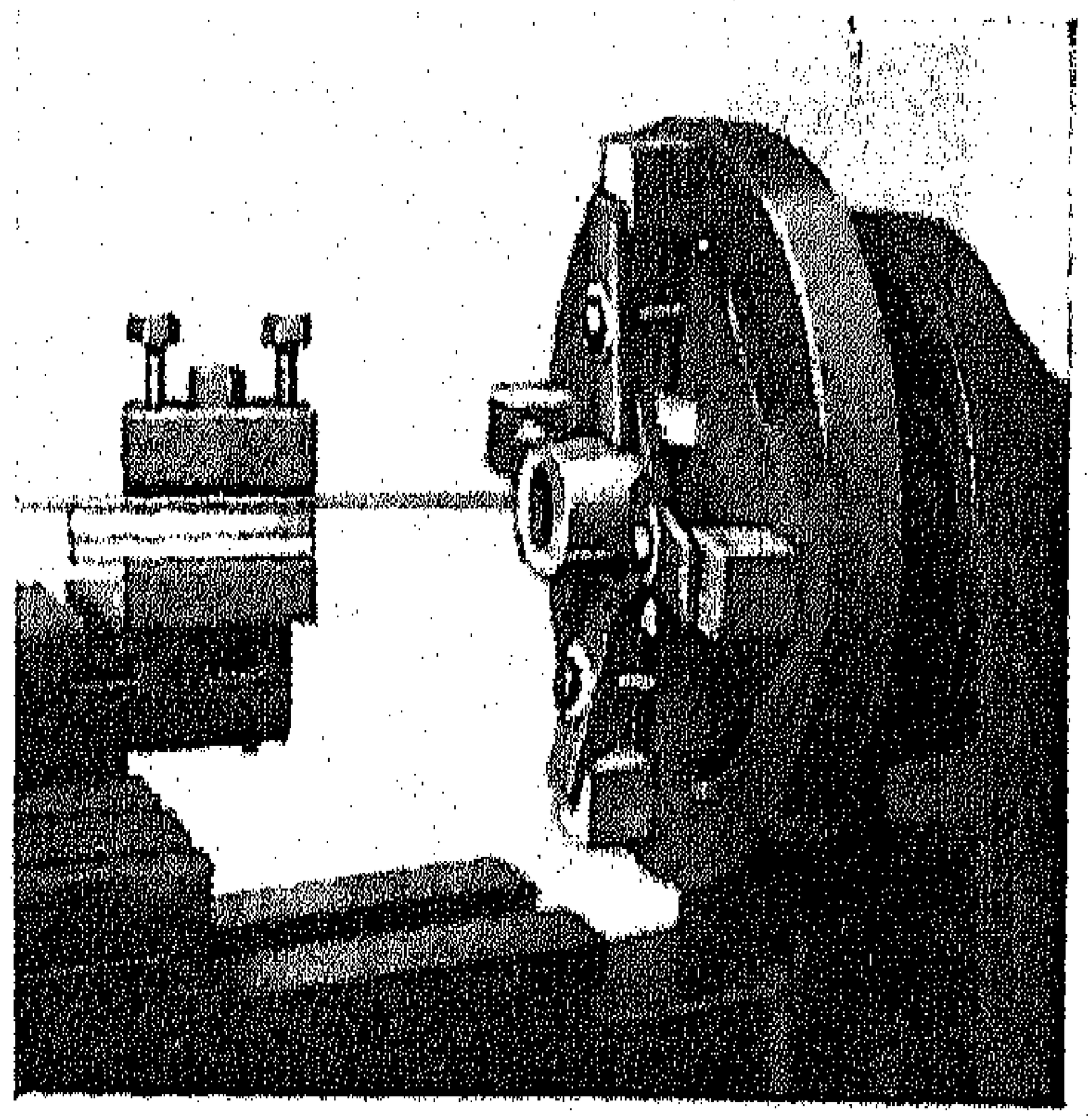


Fig. 30 B

To set up a job of this description, place a washer on each bolt and pass the shanks through the slots from the back of the plate. Slip the clamps over the bolts and twist on the nuts for a few threads down to prevent them from sliding out of the slots. Now place the work as centrally as possible on the plate, and if the plate happens to be one with a series of concentric rings marked upon its surface, so much the better, for these lines will enable you to gauge the centre. The next step is to place the hardwood blocks in position and to tighten up the nuts. As this operation may prove awkward without the use of three hands, the difficulty may be overcome by using the back headstock as a support to the work. Slide the back headstock along the bed and fix it in a position near the work. Place a flat piece of wood across the work and feed up the back centre to the work, and lock the spindle. This will enable both hands to be used for placing the blocks in position and tightening up the nuts. If the work does not run centrally, relieve the pressure on the clamps by slackening off the nuts a trifle. Give the "high" part a light tap with a hammer, not forgetting to place a piece of wood between the work and the hammer when doing this. If this is done it generally has the desired effect.

The Angle-plate.—Fig. 32 shows this device. It is used in conjunction with the face-plate where the shape of the job precludes it from being conveniently fixed in a jaw-chuck or direct on to the face-plate.

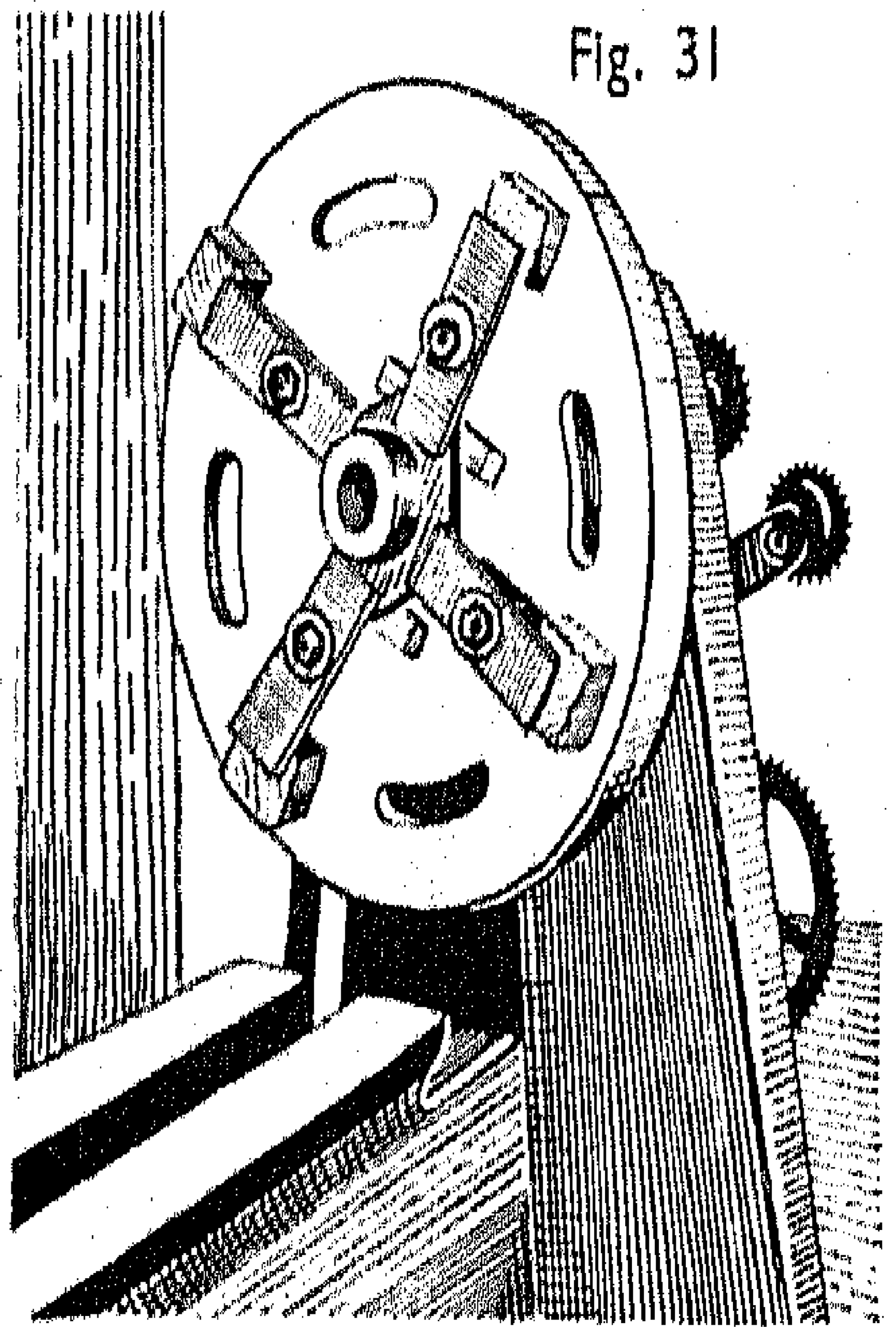


Fig. 31

On referring to the illustration it will be seen that slots are provided on each surface similar to those on the face-plate. These are needed to enable fixing bolts to be passed through them for attaching the work to the angle-plate and the angle-plate to the face-plate.

The method adopted for mounting a job on an angle-plate is shown clearly in Fig. 33. When using an angle-plate, a counterweight should always be fixed on to the face-plate in such a position as to counterbalance both the work and the angle-plate. The reason for this has already been explained. Always run the lathe at slow speed when using an angle-plate.

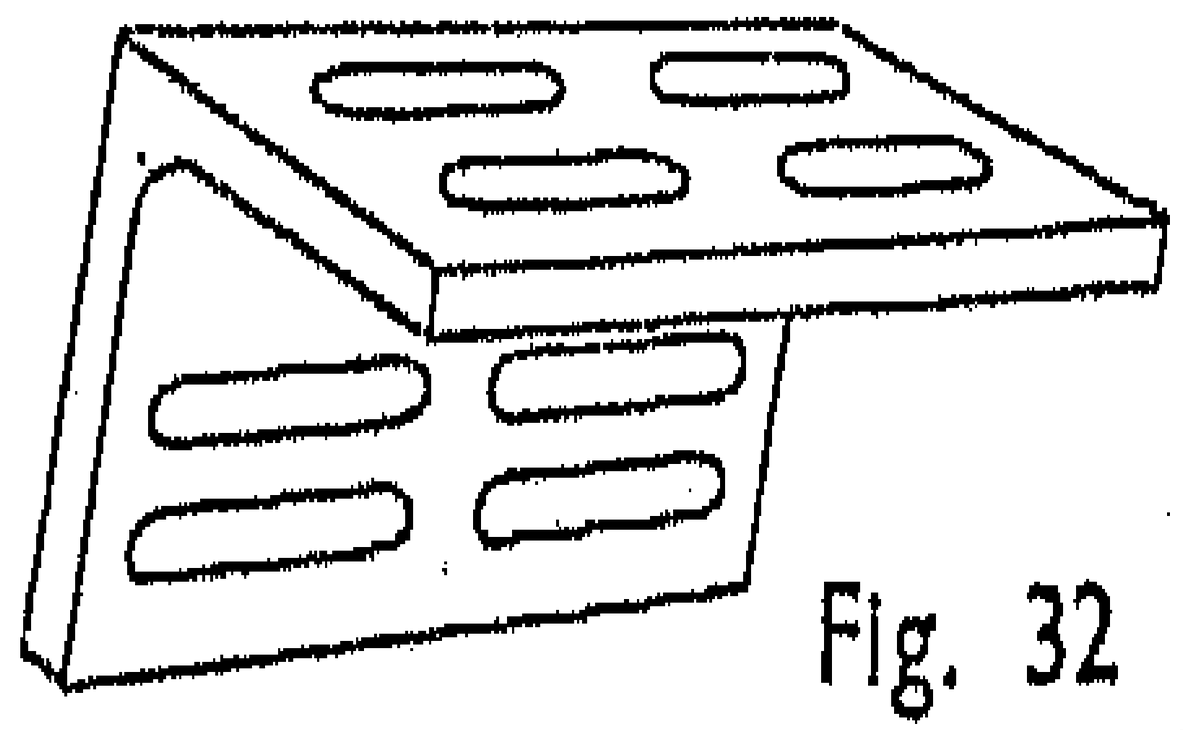


Fig. 32

The capabilities of a lathe are almost unlimited, for not only is it possible to turn all manner of external surfaces accurately and true to size, but it can be used to equally good advantage for drilling and boring.

Drilling consists in making a hole of a desired diameter in a piece of metal in one operation by the use of a drill, and is confined to work where holes of small diameter are required. The process of boring—or internal turning—is really the operation of enlarging holes already provided in the work and is generally accomplished by the application of a boring-tool.

As the process of drilling consists in the removal of a comparatively large

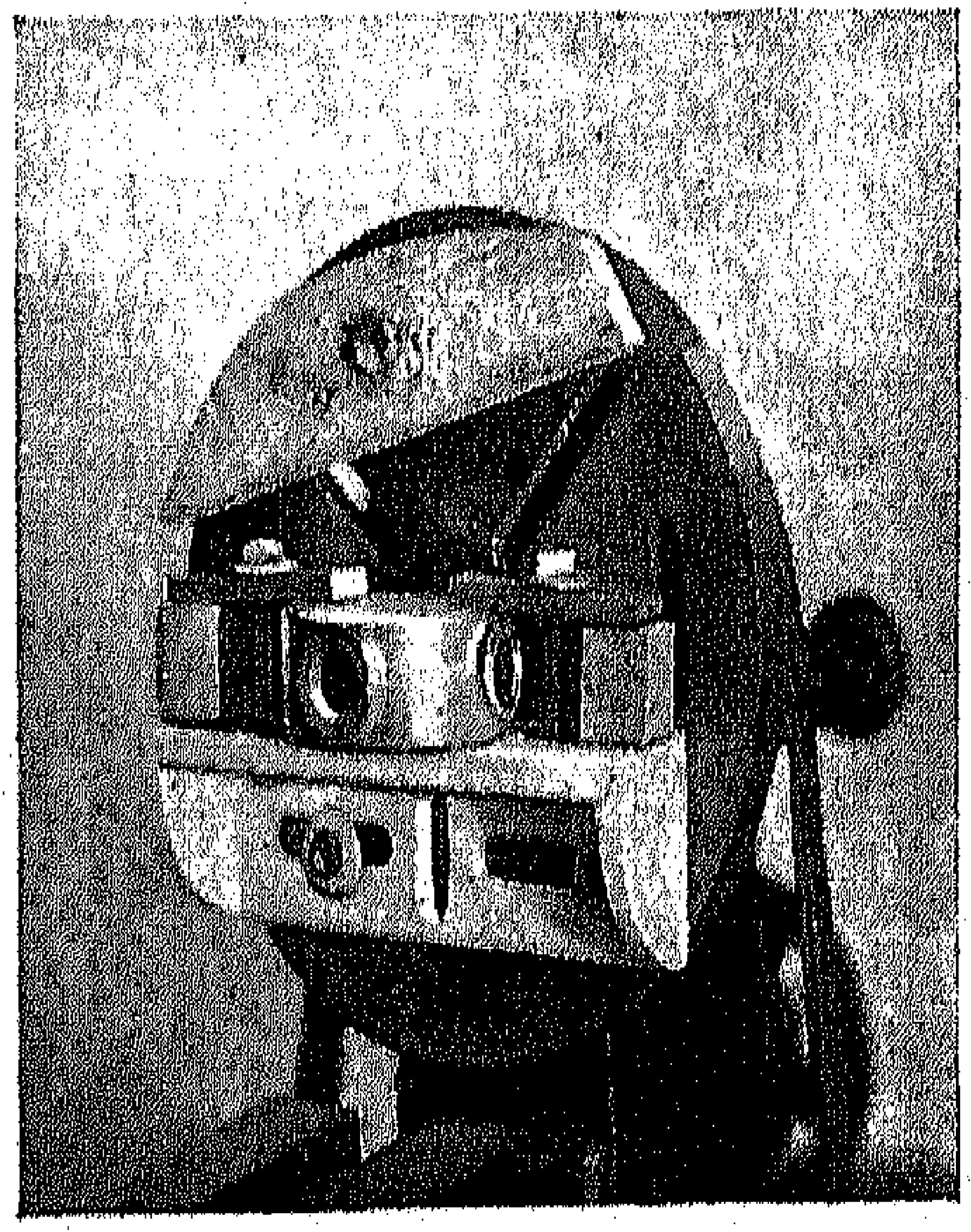


Fig. 33

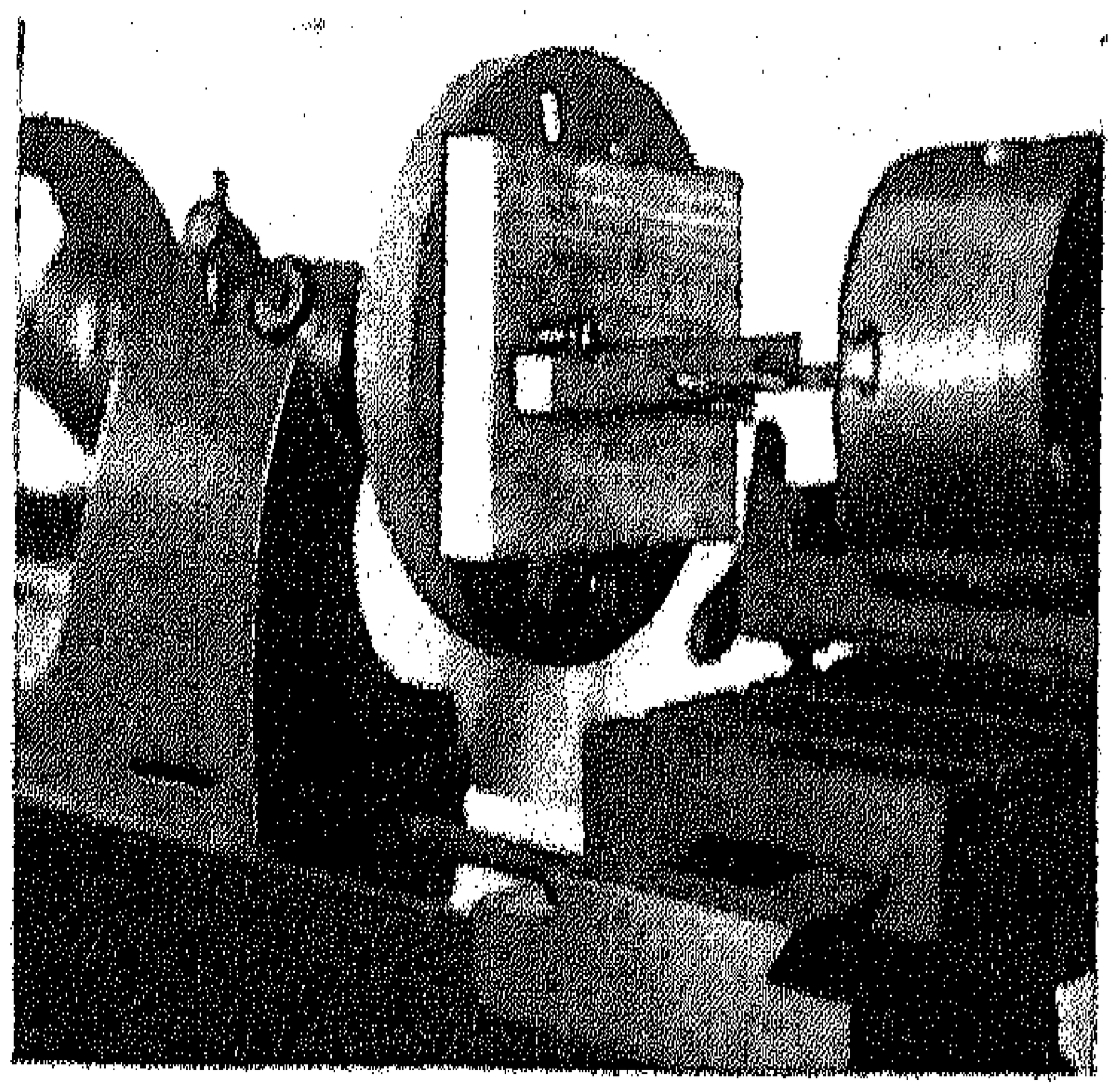


Fig. 34

quantity of metal at one operation and consequently absorbs a large amount of power, its application is limited in small lathes to the making of holes up to about ¾ in. diameter. On the other hand, boring being a process where the hole is gradually increased in size and therefore only a small amount of metal is removed at a time, holes can easily be made which are only limited in size by the size of the work operated upon.

There are numerous methods of drilling holes by the use of a lathe and Fig. 34 shows a method commonly used. An ordinary twist drill is held in a self-centering chuck and the work is fed up against the drill by means of the back centre, as will be seen from the detailed illustration. The work is placed against a drilling-plate, which is nothing more than a simple circular plate with a tapered shank at the back to fit the barrel of the loose headstock. A hole made in the centre of the plate allows the drill point to clear when it comes through the work. To drill a hole by this method, all that is necessary is first to make a deep centre-pop on the work where the hole is required—this operation should always be done where drilling is concerned. Fix a suitable-sized drill in the chuck, remove the back centre and fit the drilling-plate in its place. Move the loose headstock to a convenient position along the bed, not forgetting to fix it. Place the work flat against the plate, holding it in place with the left hand, and feed the work up to the drill with the right, taking care to see that the point of the drill corresponds with the centre-mark in the work. Start the lathe and gradually feed the work forward until the drill has cut its way through the metal.

The utility of a plain drill-plate will be greatly improved if it is provided with three screw-holes in its surface to enable a block of flat hardwood to be fastened to its surface. This will allow small pieces of work to be fixed to the surface of the wood, which would otherwise be difficult to hold with the hand. The wooden fixture is also very handy when drilling thin metal, as it prevents the work from bending when under the influence of the tool.

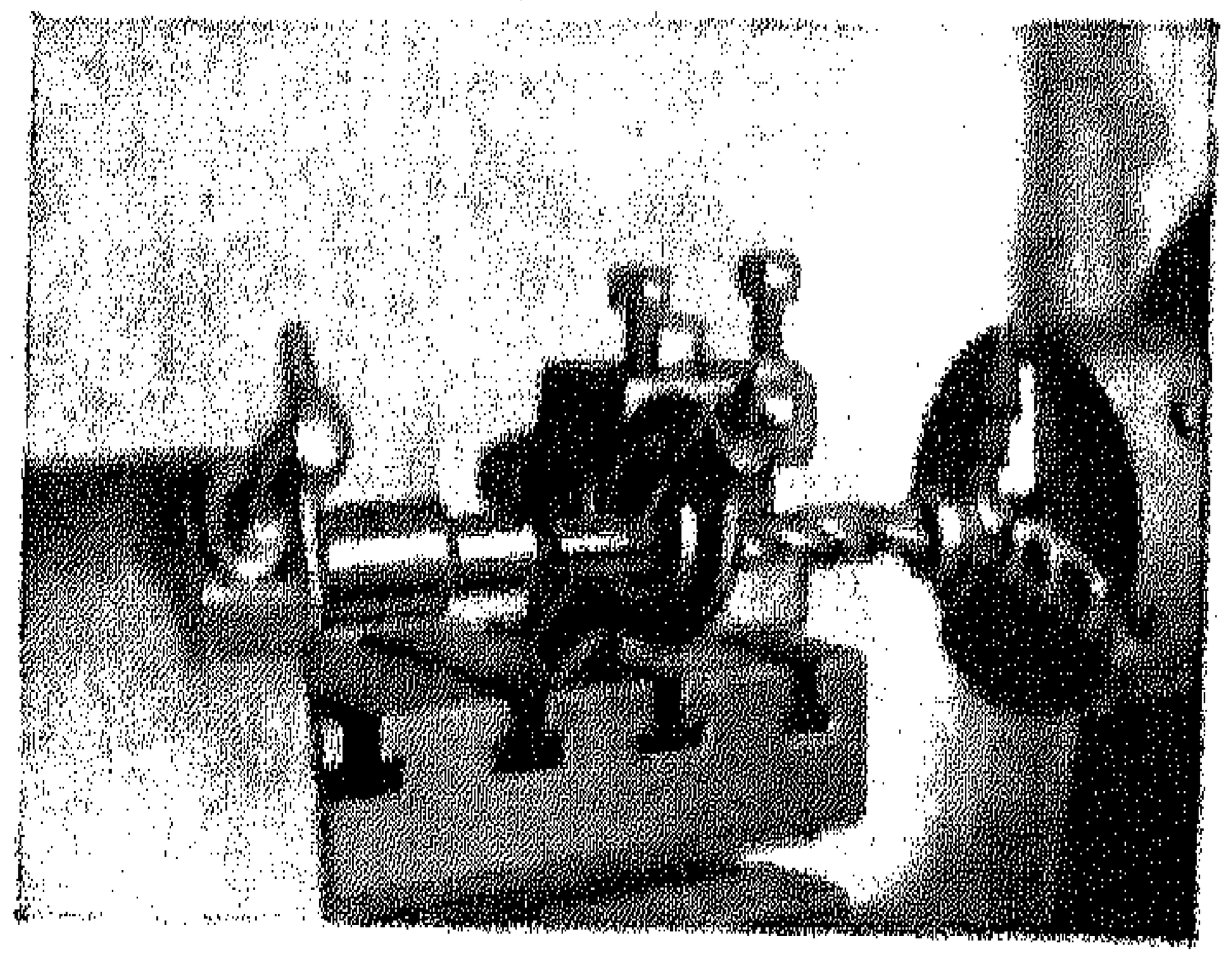


Fig. 35

A hole may be drilled through a round rod by the same process as that mentioned above, but instead of having a flat piece of hardwood to support the work, a V-shaped slot should be cut across the surface to suit the diameter of the work.

A handy method of drilling holes in jobs held in a face-plate or chuck is shown in Fig. 35. Here, the drill used, which must be one of those having a centre-hole at the end of its shank, is fixed in an ordinary lathe-carrier, which is held in the hand to prevent it from turning round, and fed up to the work. The drill must, of course, be firmly pressed against the back centre whilst drilling is in progress.

Fig. 36 illustrates a drill held rigidly in a small, adjustable chuck which fits into the back centre hole of the tailstock spindle.

For Enlarging Holes already made in a piece of work or for enlarging "cored" holes in a casting, the two methods generally used, employing flat drills, are shown in the illustration (Fig. 37). That shown at A represents the method adopted for using the drill in the slide-rest, and B that where the drill is fed by means of the back centre.

When a cored hole is to be operated upon, the following points must be carefully observed. Where the method shown at A is adopted, the tool must be rigidly fixed in the tool-post of the slide-rest. The drill must also be fixed in a central position and at the correct height corresponding to the height of the lathe-centre, otherwise the tool will follow the course of the cored hole, which is usually out of truth. When all these conditions have been satisfied, the drill can be gently fed up to the work by the feed-screw of the top-slide.

The alternative way of using a flat drill for enlarging holes is shown in Fig. 37 at B. On referring to the illustration, it will be seen that instead of the drill being rigidly held in the slide-rest, it passes through a slotted bar, as represented at X, which is held in position in the top slide of the slide-rest. The back end of the drill has a centre-hole to enable the tool to be placed against the back centre and fed up to the work. To keep the drill steady, a piece of flat iron in the shape of a hook is used at the back end.

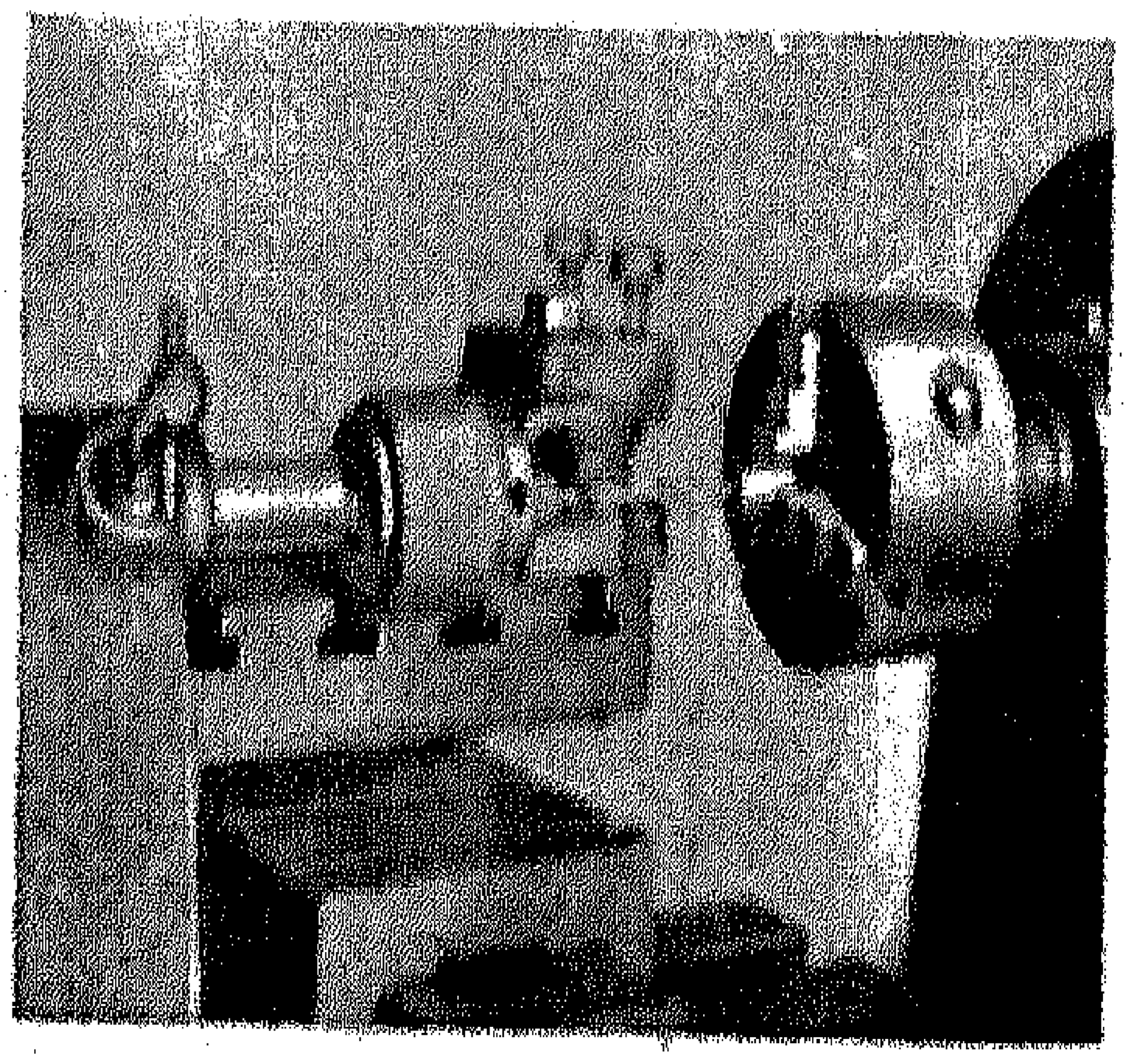


Fig. 36

To operate the drill, the back holder is pressed downwards either by the left hand or by means of a weight (W), suspended from the end, while the back centre is fed up to the work by using the right hand.

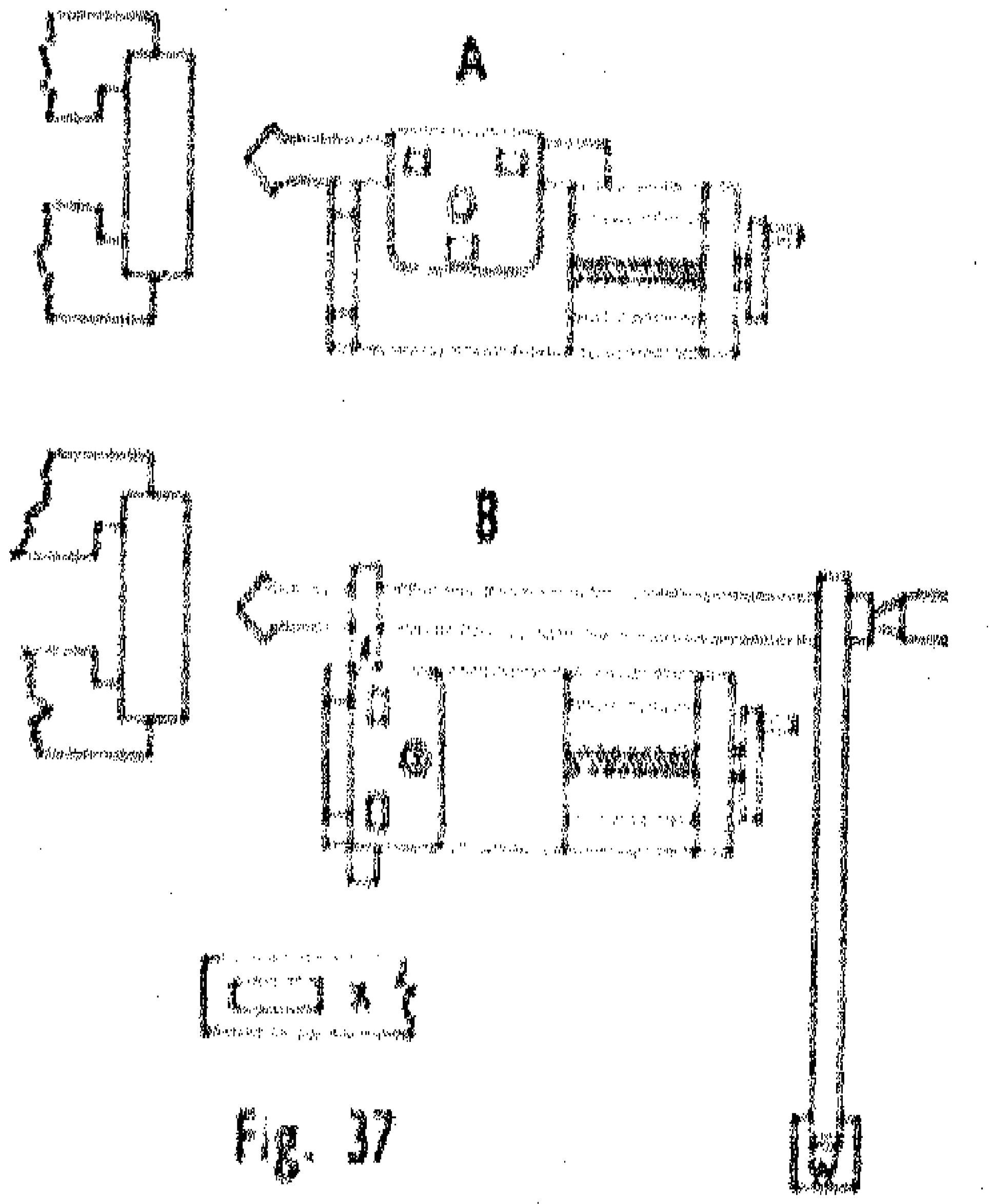


Fig. 37

Boring is one of the most important processes applicable to metal-turning, and as so many jobs have to be bored, some general information on the subject will no doubt be useful.

There are two common methods used in the process of boring, the first—which is the one usually adopted for general work—where the cutting-tool is stationary and operates upon the revolving work held in a chuck or face-plate; the second, where the work is stationary and is operated upon by a revolving cutter, applicable to lathes fitted with a self-acting saddle.

Fig. 38 shows a piece of work

mounted upon a face-plate, with an ordinary slide-rest boring-tool fixed in position ready for boring.

In preparing such a piece of work preparatory to the actual process of boring, there are one or two points to be carefully observed. The boring-tool must be of the correct shape to suit the metal to be turned, and it must also have sufficient clearance to enable the end to clear the work at the end of the cut, should there not be sufficient space behind the job being operated on to allow for this. The tool must also have proper under-clearance, otherwise the tool will rub against the work. When mounting the work in either a chuck or a face-plate, see that it is placed centrally as already explained, and furthermore, if it is possible to keep the work clear of the flat surface of the holding-device, so much the better, for this will allow the point of the tool to clear at the end of the work. Sometimes it is possible to interpose packing-pieces between the end of the work and the face-plate, as shown in Fig. 39.

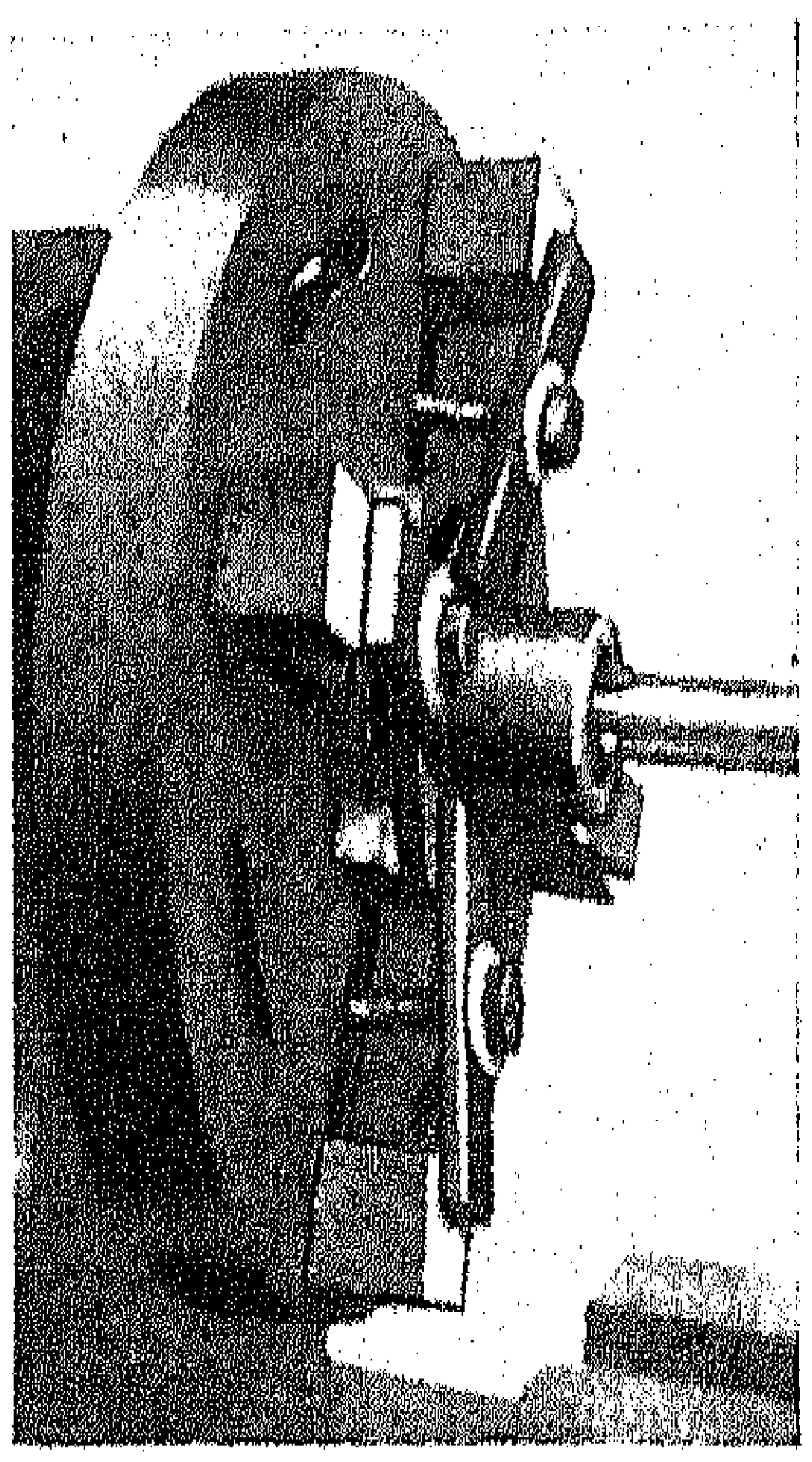


Fig. 38

Having fixed a suitable boring-tool at its correct position and height in the slide-rest—which, of course, is parallel to the lathe-bed—the tool can either be fed through the work by hand, by using the top-slide, or by the self-acting feed, if the lathe is so provided. Start up the lathe and, if the work be a casting, take a fairly heavy roughing-cut to enable the cutting edge of the tool to get right under the "skin" of the metal, otherwise the point of the tool will almost certainly get ruined owing to the grinding action of particles of sand on the surface of the casting. When the tool has reached the bottom of the hole, withdraw the tool and stop the lathe. If the operation has been properly done, the hole should be found perfectly true and parallel when tested with a pair of inside callipers. If the hole is found to be tapered either way, the slide-rest, if this is being used, must be set over a trifle in one direction or the other as the case may be. Now take a light cut, and, if the hole is found to be parallel, a further light finishing cut may be taken to complete the job.

Here a word of warning may be opportune. If the work being bored is of a light nature, it may be necessary to slack off the jaws of the chuck, or the clamps, where a face-plate is used, before taking the finishing cut. This will relieve the pressure on the work and allow the work to resume its normal shape, which may have become a little distorted due to the gripping pressure of the holding device.

The Boring Steady is illustrated in Fig. 40. It is used in conjunction with a jaw-chuck for supporting the ends of tubes, pipes, or work of a similar nature where the ends are required to be bored or threaded. The device can be made of two pieces of flat hardwood, 1 in. thick, fixed at right-angles to each other by means of substantial angle-brackets, as shown.

The upright piece is bored out to fit the outside diameter of the work, and the steady is held in position across the lathe-bed by means of a bolt running through the base, between the bed, and a clamping-plate underneath.

Fig. 41 shows a method of boring work in a self-acting lathe by means of a boring bar carrying a cutter, driven between the lathe-centres. Here it will be seen that the work is bolted down to the saddle after the removal of the slide-rest. This method of boring is adopted when the job is too awkward in shape or too heavy to be properly held in a chuck or face-plate.

The first thing to do when this method of boring is used, is to mark out accurately the position and the finished size of the hole at each end of the work. This can be easily done if pieces of flat wood are inserted at each end of the work to obtain a flat surface. With a pair of compasses mark on the work a circle of the exact diameter the finished hole is to be, and make a series of centre-pop marks on this circle. Now bolt down the work in position on the saddle, leaving the fastening nuts slack. Pass the boring-bar through the work and suspend it between centres. Next, fix a scriber in the cutter hole of the bar by means of a wooden wedge, in such a position that when the bar is revolved by hand the point of the scriber describes a circle of the same diameter as that marked on the work. Adjust the work until the scriber-point just touches the circle on the work at every point on each end. When this is accomplished, the nuts of the holding bolts may be finally tightened up.

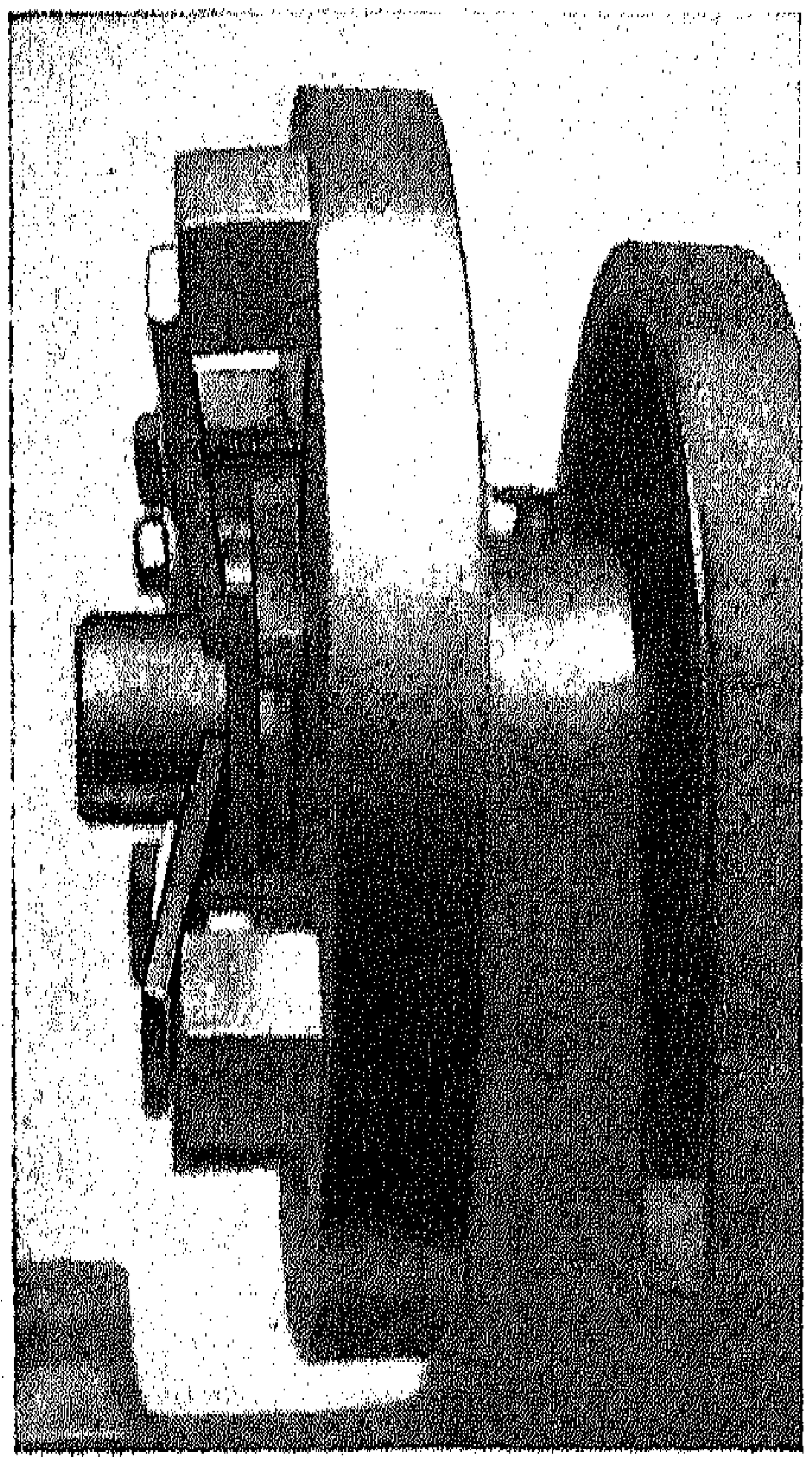


Fig. 39

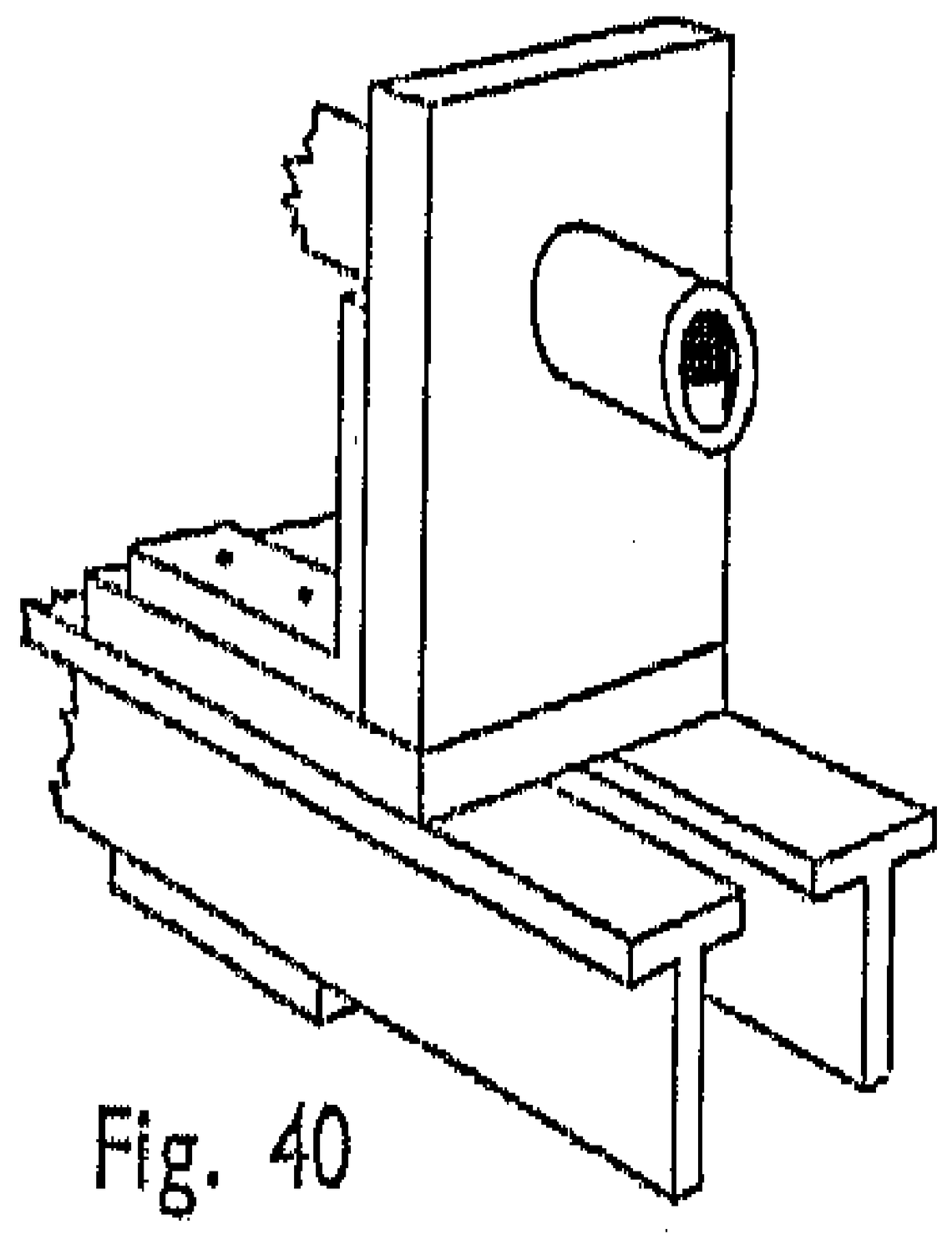


Fig. 40

The Cutter.—In Fig. 42 at A is shown a common form used in a boring-bar. It consists of a small piece of round tool steel which fits into a hole in the bar and is kept in position by a small set-screw. This type of cutter is used for boring comparatively small holes. For boring holes of large diameter, the boring-bar is sometimes fitted with a boring-block, which is indicated at B in the illustration. This device has the advantage that it enables the tool to be well supported. It consists of a collar keyed to the bar, and the cutter

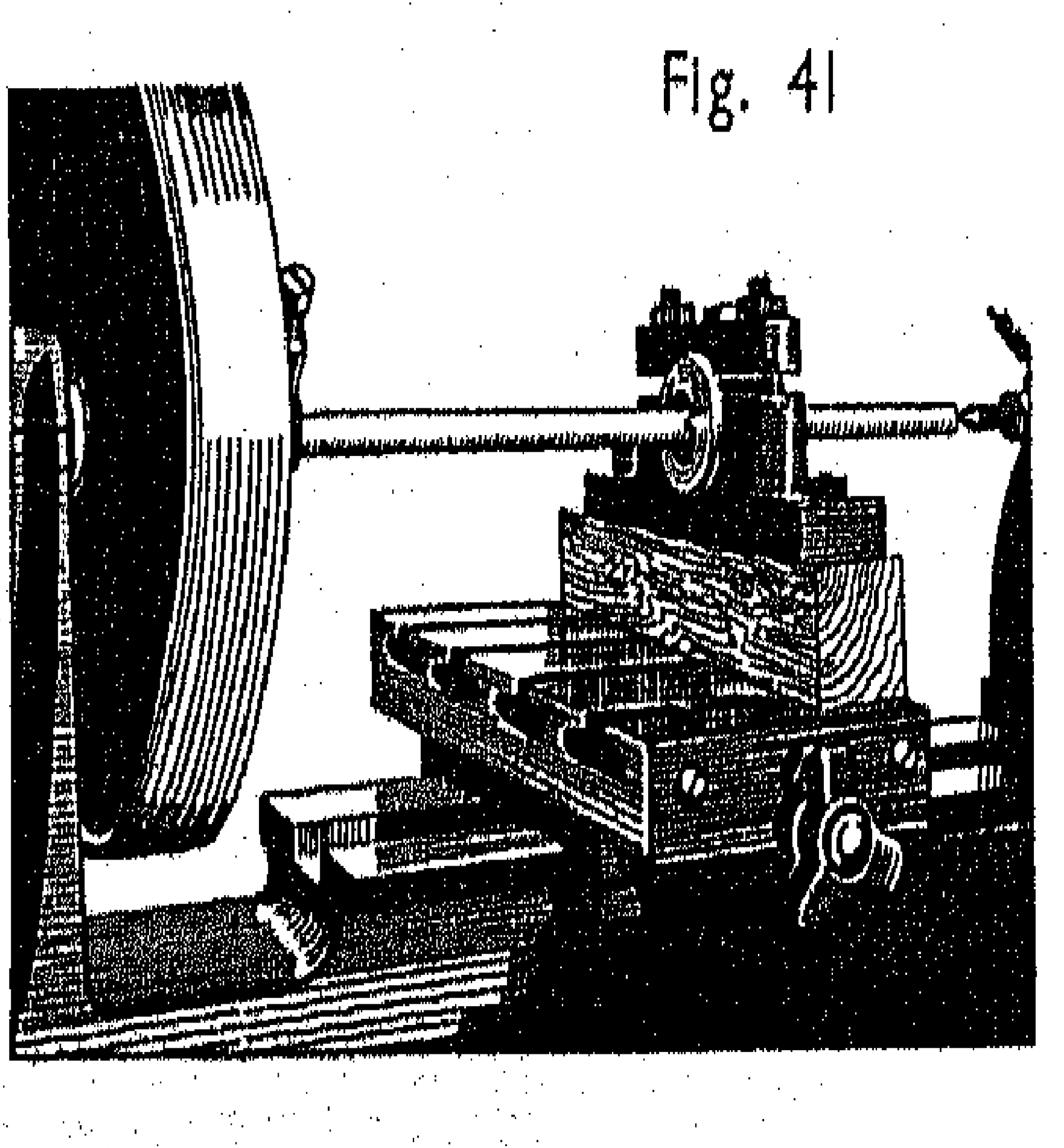


Fig. 41

is held in the collar by a set-screw as indicated in the sketch.

Another form of tool for special use with a boring-bar is a double-ended cutter, made of cast steel, suitably hardened and tempered. As this type of cutter cannot be adjusted, it follows that it will only cut a hole of the same diameter as that of the cutter. Such a tool produces excellent holes, but is rather difficult to make, and therefore generally outside the scope of the amateur.

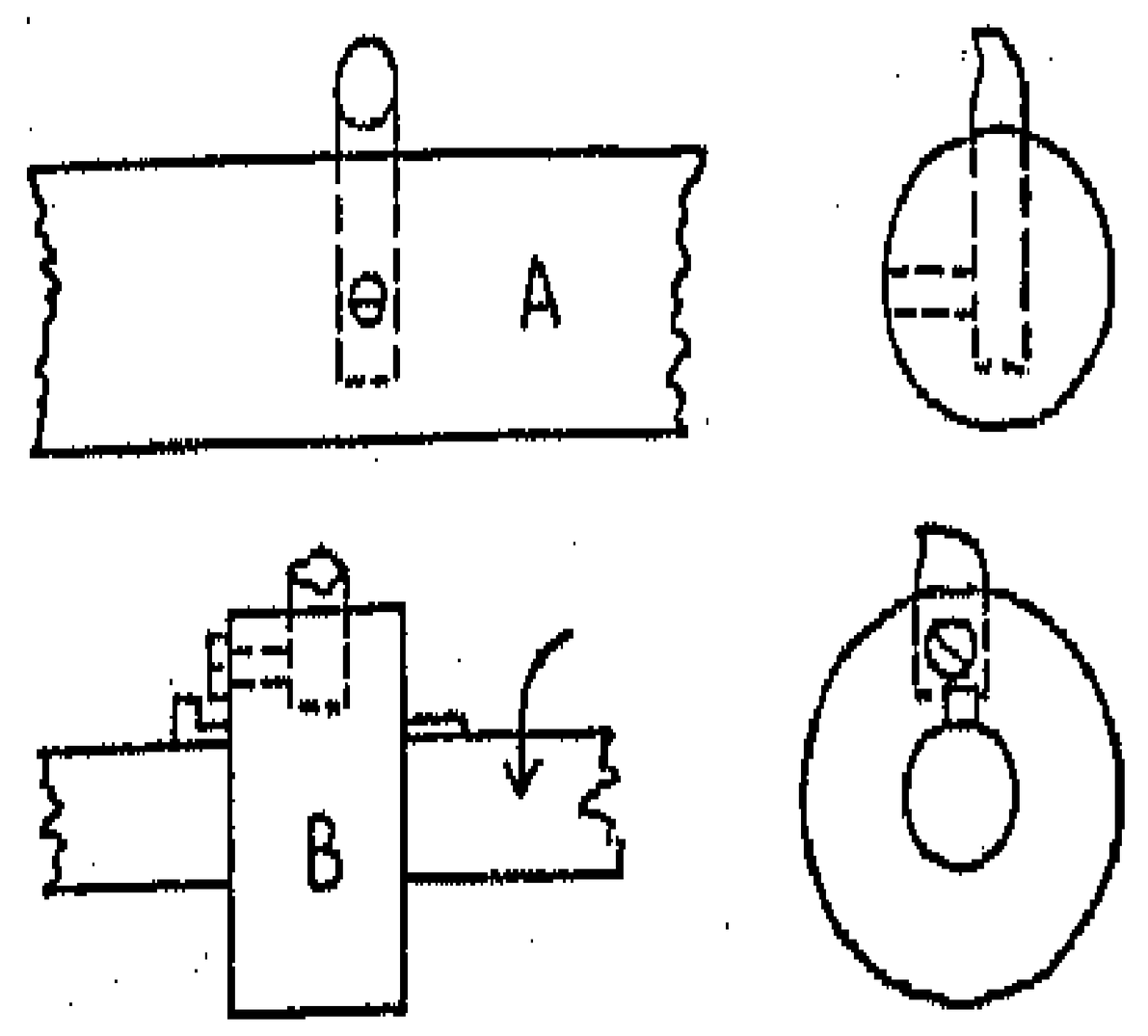


Fig. 42

As modern lathes are nearly all equipped with suitable apparatus for cutting screws, the arrangements of this extremely important process and the tools necessary for carrying out the work will now be examined.

Screw-cutting.—Many amateur craftsmen are deterred from "trying their hand" at screw-cutting for no other reason than that they are under the impression that screw-cutting is an extremely difficult and mysterious operation and calls for a vast number of mathematical calculations. This is quite an erroneous idea, for screw-cutting demands very little more skill than ordinary turning and boring, and once the principles involved are grasped and a little practice obtained, screw-cutting becomes both a fascinating and interesting operation.

To cut a screw in a lathe some arrangement must be adopted to move the tool along the bed at a perfectly uniform rate. This is obtained by means of a lead-screw and a system of change-wheels which are fitted to the lathe-spindle and the lead-screw. As stated elsewhere, the saddle has a split nut, which, when closed, engages with the threads of the lead-screw, and when revolved causes the saddle to move along the lathe-bed at a definite speed in relation to the spindle.

The lead-screws of some lathes are provided with threads having a pitch of $\frac{1}{4}$ in., or what is the same thing, four threads to the inch. Now, it follows that when the split nut is engaged with the lead-screw and the lead-screw makes one revolution, the saddle will travel along the bed a distance equal to the pitch of the lead-screw. If a bar of metal is suspended between centres and a fine tool inserted in the tool-holder so that it just touches the work, and the gearing so arranged as to cause the lathe spindle to revolve at the same speed as the lead-screw, then the tool will trace a spiral of exactly $\frac{1}{4}$-in. pitch on the work. It will thus be seen that if the work is revolved at the same speed as that of the lead-screw a thread will be made equal in pitch to that of the lead-screw. Now suppose that the work makes two revolutions to one of the lead-screw, then the saddle will move only $\frac{1}{8}$ in. during one revolution, and the tool will trace eight spirals of $\frac{1}{8}$-in. pitch in the length of one inch.

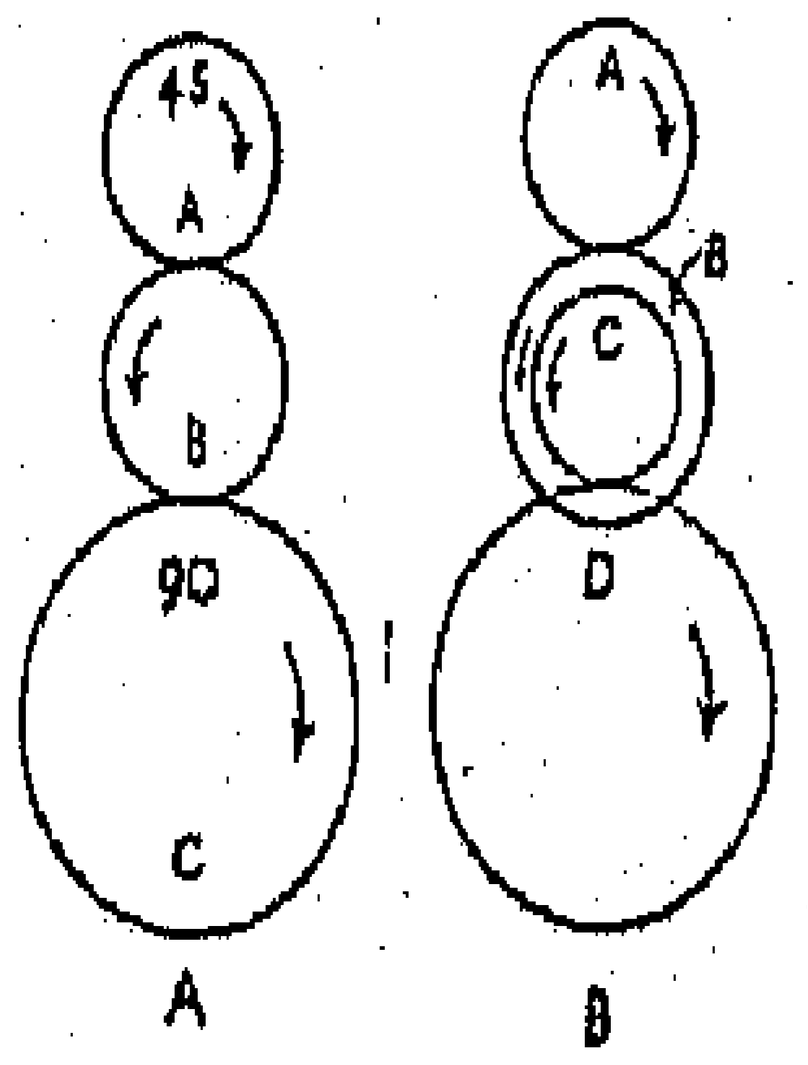


Fig. 43

Such variations of speed between the lead-screw and the lathe spindle are obtained by means of a train of toothed gear-wheels.

From the above it is easy to see that a train of gear-wheels driving the lead-screw will result in a screw of a definite pitch. The diagram at A in Fig. 43 shows a simple train of wheels set up for cutting a right-handed thread. Here, A represents the mandrel wheel which gears into an intermediate wheel (B), which in turn transmits motion to the lead-screw wheel (C). In this particular instance, suppose a screw having eight threads to the inch is required. As the lead-screw is assumed to have four, it follows that the work must revolve twice as fast as the lead-screw and produce a thread on the work of the desired pitch. To obtain this ratio of speed, a 45-tooth wheel is shown driving a 90-tooth wheel through an intermediate wheel, which may have any convenient number of teeth, as it is simply used to transmit motion from A to C.

The rule for calculating the size of the change wheels to cut threads of different pitches is as follows:

$$\frac{\text{Pitch of lead-screw} = \text{PL}}{\text{Pitch of screw to be cut} = \text{PS}} = \frac{\text{Wheel on mandrel (driver)} = \text{WM}}{\text{Wheel on lead-screw (driven)} = \text{WL}}$$

The following example will make this clear:

What change wheels are necessary to cut a screw having eight threads per inch, assuming that the lead-screw has a pitch of $\frac{1}{4}$ in.?

Here $$\frac{\text{PL}}{\text{PS}} = \frac{\text{WM}}{\text{WL}}$$

substituting values we have:

$$\frac{\frac{1}{4}}{\frac{1}{8}} = \frac{\text{WM}}{\text{WL}} = \frac{4}{8} = \frac{1}{2}$$

Therefore any two wheels having the proportion of 1 : 2 will answer the purpose. Thus a 20-tooth wheel on the mandrel and 40-tooth wheel on the lead-screw would do, or a 30 and 60 and so on.

These wheels would be geared together by inserting an intermediate wheel of any size to fit conveniently.

Here is another example. A screw-thread having nine threads per inch has to be cut in the same lathe, what change wheels are necessary?

Here the proportion is $\frac{4}{9}$ so that a 40 and a 90 will serve, as also will a 20 and 45, as these wheels are in the same ratio.

Suppose the same thread is cut in a lathe having a lead-screw of $\frac{1}{2}$-in. pitch, then the ratio would be $\frac{2}{9}$, so that a 20 and a 90 would suffice.

It frequently happens that a simple train of wheels such as those mentioned above cannot be used owing to not having the necessary sized wheels available. In such a case a compound train of wheels would be used. This contingency usually arises when it is desired to cut threads of fine pitch. For instance, if a thread of 35 threads per inch is required, and the lead-screw has four threads per inch, the proportion is 4 : 35. As the smallest change wheel has only 20 teeth and the largest 120, it follows that to use a simple train would involve using a wheel of 20 teeth on the mandrel and one with 175 teeth on the lead-screw.

An arrangement of a compound train of gear-wheels is shown in diagram B, Fig. 43. The wheel A is attached to the mandrel, wheels B and C are keyed together and mounted on a stud on the bracket, wheel B being geared with A, whilst wheel C is in mesh with D on the end of the lead-screw. Wheel A is known as the first driver, wheel B, the first driven wheel; wheel C the second driver and wheel D the second driven wheel.

The following examples show how to select change wheels when it is necessary to use a compound train.

Calculate a set of change wheels to cut a screw of 35 threads per inch, with a lead-screw having four threads per inch.

Here the ratio is worked out in the same manner as that used for a simple train.

The ratio, in this case, will be:

$$\frac{\frac{1}{35}}{\frac{1}{4}} = \frac{4}{35} = 4 : 35$$

Both the numerator and denominator of this ratio can be multiplied by any number without altering the ratio. As the two smallest in the set is 20 and 25, it is no use to have a numerator less than 500. Multiply both the numerator of the fraction 4/35 by 200; thus $\frac{4}{35} \times \frac{200}{200}$

This will give $\frac{800}{7000}$ Now split the numerator and denominator into factors, as follows:

$$\frac{800}{7000} = \frac{20 \times 40}{70 \times 100}$$

Thus, a set of wheels having 20 teeth and 40 teeth as drivers, and 70 teeth and 100 teeth as the driven wheels would be a perfectly satisfactory combination to use because these sized wheels are usually available.

These wheels would be set up in the following way. The 20 wheel would be fixed to the spindle driving the 70 on the stud; the 40-toothed wheel would be keyed to the 70 on the stud to drive the 100 wheel on the lead-screw.

If both the numerator and denominator in the above example had been multiplied by 300 instead of 200, the resulting combination of wheels would have been as follows:

$$\frac{4}{35} \times \frac{300}{300} = \frac{1200}{10500}$$

This fraction split into factors is $\frac{30 \times 40}{100 \times 105}$ which would suffice equally as well.

Here is another example. What sized change wheels are required to cut a thread 7/24-in. pitch if the lead-screw is $\frac{1}{2}$ in.?

$$\text{The ratio} = \frac{\frac{7}{24}}{\frac{1}{2}} = \frac{7}{12}$$

In this case it will be observed at once that a simple train consisting of a 70 wheel on the spindle and a wheel of 120 teeth on the lead-screw would answer the purpose.

Note carefully when fixing up a train of gear-wheels to see that the tops of the teeth on one wheel do not foul the bottoms of the wheel it is in mesh with. Failure to observe this precaution may result in broken teeth. Another point to observe is that it is good practice always to arrange a train of wheels with wheels as large as possible, and where it is necessary to use wheels of small diameter they should be fitted as near to the source of power as possible, that is, the spindle.

Cutting a Screw Thread.—The actual operation is not a very difficult job, but a certain amount of care is required.

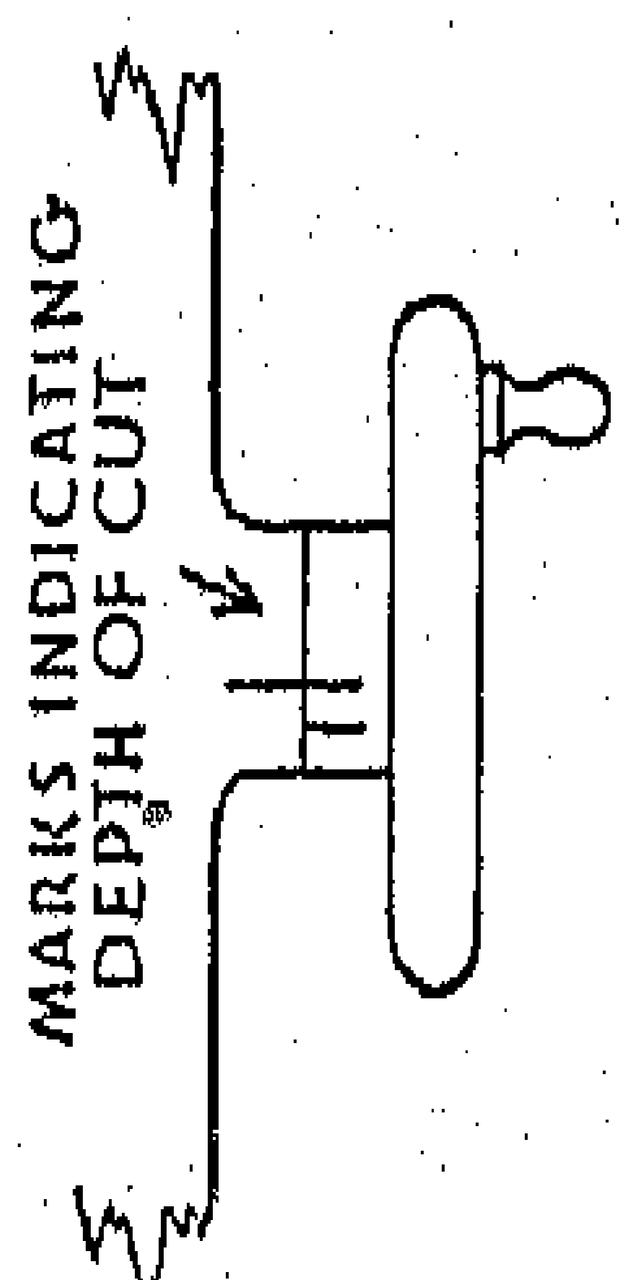


Fig. 44

When the necessary train of screw-cutting change wheels has been set up, mount the work between centres and fix a suitable tool in the slide-rest. Start up the lathe and give sufficient inward feed to the tool to give a light cut. A heavy cut should not be attempted as there is danger of breaking the somewhat fragile tool. Note the amount of cut given by marking the shoulder of the cross-slide handle, using a piece of chalk for the purpose, as shown in the illustration (Fig. 44). This will serve as a guide for judging the depth when making succeeding cuts. Next, engage the split nut and take a trial cut along the work; withdraw the tool and disengage the nut from the lead-screw and run the saddle

back to its original position. Feed the tool forward to give the same depth of cut as the previous one—providing, of course, that it is satisfactory—using the chalk-mark as a guide, and mark the new position on the feed handle as before. Repeat the operations until the threads are cut to the correct depth.

If the lathe is of a modern type which is usually provided with graduated scales on the slide-rest handles, it is obviously unnecessary to chalk-mark the position for the depth of cut.

Before going any further it is necessary here to point out that the tool must, of course, always follow the same path at each successive cut, that is to say, the tool must always follow in the thread at every cut. If this is not so, the point of the tool would not be opposite the bottom of that part of the thread already cut, with the obvious result that the partially made thread would be ruined. Caution, however, need only be observed where threads are being cut which are not an exact multiple of the threads on the lead-screw, for the tool will always follow the thread when the threads being cut are an exact multiple of the leading-screw threads.

When the threads per inch to be cut on the work are not an exact multiple of the threads per inch of the lead-screw, after the first cut, the clasp-nut must only be engaged at certain instants.

To enable the tool to follow the thread at the proper time when cutting such a thread it is a good plan to bring the saddle right back so that it touches the back headstock, or, if this is impracticable, to bring the saddle back to a line marked across the lathe bed. It is also necessary to make a chalk-mark on the top of the lead-screw, or, better still, the gear wheel attached to it, and a similar chalk-mark on either the holding device or the first driving wheel on the mandrel spindle. After the first traverse, the clasp-nut should be released and the saddle moved back to the back headstock (or other marked position), and then when the two chalk-marks come into their original position, the clasp-nut may be closed and the next cut made.

Multiple-thread Screws are generally used to replace a single thread of coarse pitch where the bottom diameter is too shallow for practical purposes. The depth of the threads of double-thread screws is only one-half that of single threads, while that of triple-thread screws is only one-third. The pitch of the screw, of course, remains the same, and the change wheels are calculated in the usual manner, as already described.

To Cut a Double-thread Screw, first cut a thread of one-half the depth and width of a single thread of the same pitch. Next, find the correct starting-point for the second thread, which obviously comes midway between the threads already cut. Make a chalk-mark on a tooth of the first driving change wheel—which should have an even number of teeth—and also mark the space occupied by the tooth in the follower or driven wheel. Now mark the tooth exactly opposite the one already marked on the driver. Lower the bracket or swing plate a trifle and turn the lathe spindle half a revolution so that the second marked tooth engages with the marked space on the follower. Start the lathe and cut the second thread, which will be in the correct position if the foregoing instructions have been faithfully carried out.

To Cut a Triple-thread Screw, proceed in a similar manner to that described above, but as three threads are required, three equal divisions are necessary on the driving change wheel. The number of teeth in this wheel should be a multiple of three, such as 30 or 45.

Sometimes it is necessary to cut a left-handed screw. In this case the lead-screw must revolve in the opposite direction to that of the work. The cut is started at the left-hand end of the work. The change wheels are calculated in the usual way. The reverse motion is imparted to the lead-screw by inserting an extra wheel in the train of gear wheels between the mandrel and the lead-screw, as shown at A in the diagram (Fig. 45).

Tools for screw-cutting are of special shape.

For Cutting V-thread Screws a single-pointed tool is generally used. Fig. 46 shows such a tool. If the threads to be cut are Whitworth threads, the straight sides of the thread are included in an angle of 55° with one another, and the tops and bottoms of the threads are rounded to a radius of ·137 of the pitch, so the point of the tool should not be sharp, but slightly rounded. Also, the front part of the tool is not vertical, but is slightly canted over to prevent the tool rubbing the sides of the threads. Top and bottom rake, and clearance at each side, similar to that in a parting tool, are, of course, necessary.

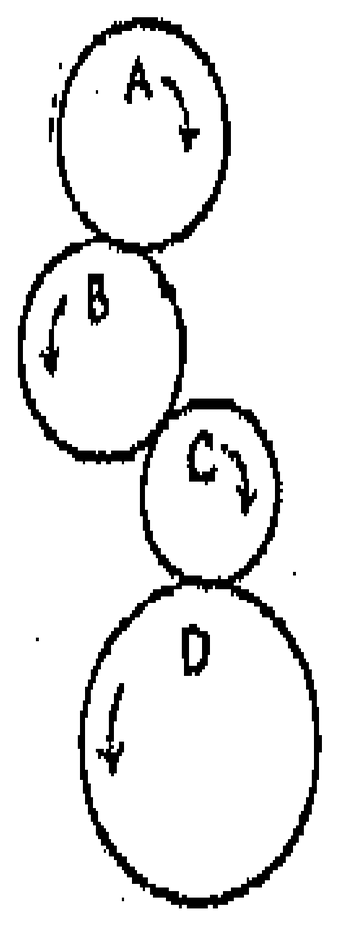


Fig. 45

From what has already been said it would appear that one cutting tool would only be suitable for cutting one particular pitch of thread. This is not necessary in practice, where small pitched threads are concerned, the reason being that the clearance angle of the cutting-edges of the tool is usually sufficient to allow for small variations in the rake of the thread.

In order to finish off a thread to its exact shape—that is, with the correct radius at the top and bottom of the thread—a chasing tool (shown in Fig. 47) is generally used. As this tool is only used for very light finishing cuts, it is usually fitted with a handle and used by hand. To do this, fix a square bar in the slide-rest parallel to the axis and as close up to the work as possible, and run the chaser along the threads, using very light pressure only. A chasing tool is made for one particular pitch of thread, so it is necessary to have a separate chaser for every pitch of thread it is desired to cut. Chasers can also be obtained for finishing threads on internal work.

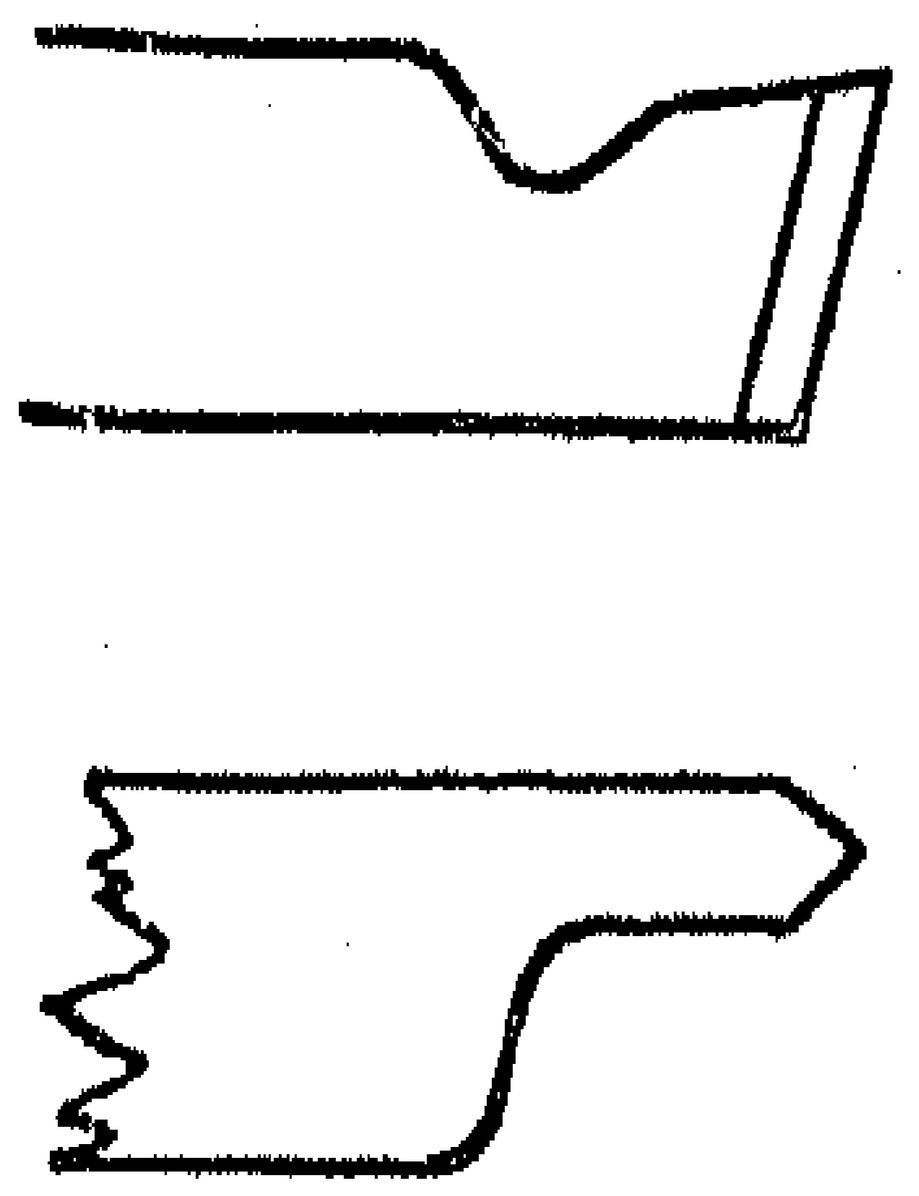


Fig. 46

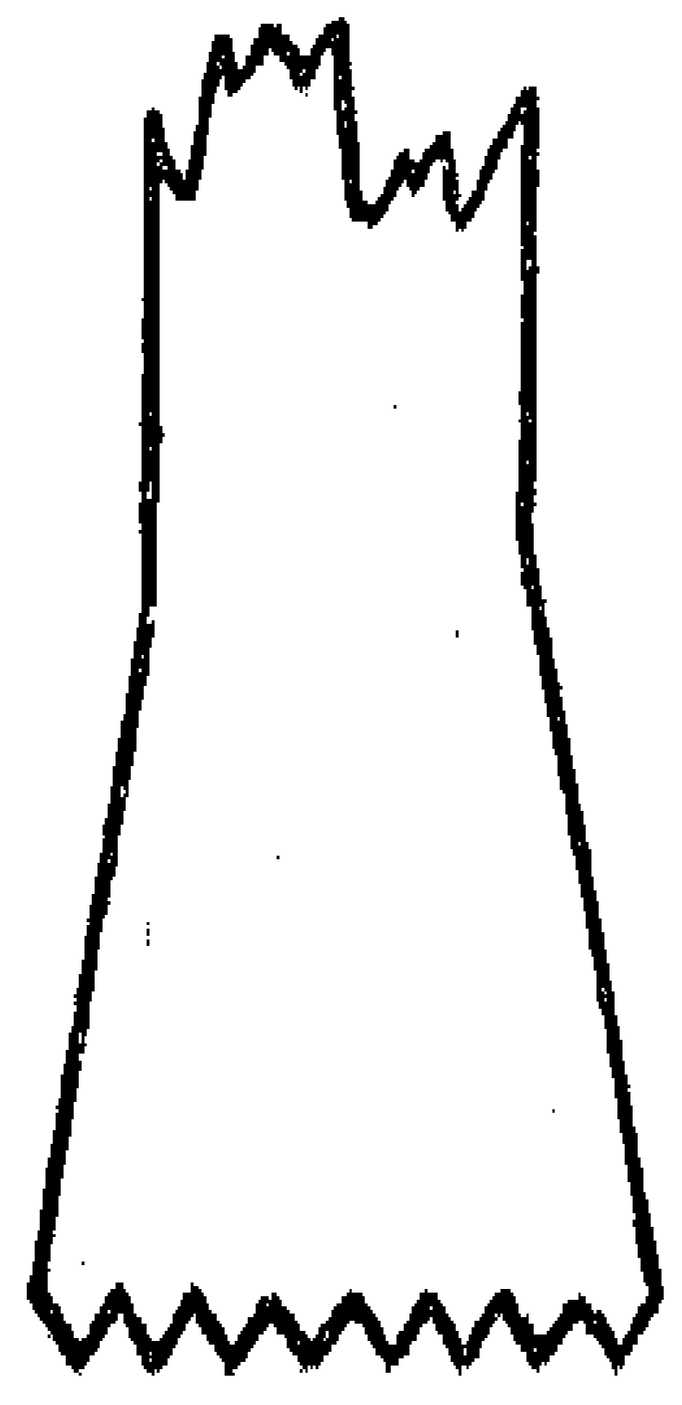


Fig. 47

A Tool for Cutting Internal V-threads is shown in Fig. 48. It is similar to an ordinary boring tool except that it is provided with a cutting point made to the correct angle of the thread, as in the external V-threading tool.

An extremely useful little tool in the form of a screw-cutting gauge, which can be purchased for a few pence, is pictured at A in Fig. 49. By its use the correct angle of the cutting tool can be easily tested, and it serves as a useful guide when setting up the tool in the slide-rest. The method of using the gauge will be readily understood by referring to B and C in the illustration, which shows the gauge being used for setting the tool for cutting external threads and internal threads respectively.

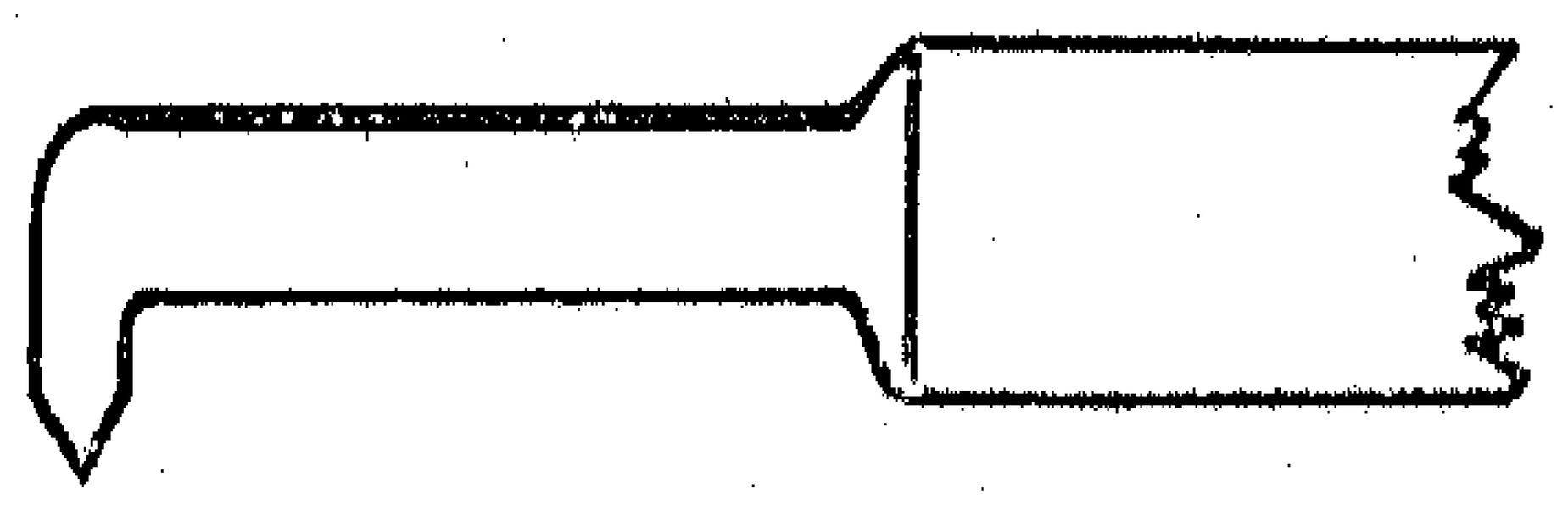


Fig. 48

In using slide-rest tools for cutting external and internal square threads, it is important to see the front slope or rake is made to correspond with the pitch of the screw to be cut. The width of the tool for cutting a single square thread is equal to one-half the pitch of the thread, while that of a tool for producing a double thread is one-quarter of the pitch, and one-sixth for a triple thread.

Before bringing this brief survey of metal-turning to a conclusion, it would be incomplete if a few words on the important subject of speeds, feeds, and lubrication were omitted.

The speed and size of cut in metal-turning depend upon the material, tools, and the efficiency and rigidity of the machine being used. Thus, for turning cast iron, using tools of high-speed steel, which are now usually adopted, the approximate cutting speed would be in the neighbourhood of 25 ft. per minute; mild steel 60; cast steel 35, and brass 120. If carbon steel tools are used, then the above speeds would be reduced by about 25 per cent. When boring the above metals the speeds should be reduced from 25 per cent. to 50 per cent., and for screw-cutting 40 per cent. to 60 per cent. In turning a piece of work it is more economical to take a moderately heavy cut at medium speed than a light cut at high speed, and also a deep cut with small traverse is better than a light cut with a rapid traverse.

Lubrication.—Some metals are turned dry and others require a lubricant. Mild steel and wrought iron require a good supply of soap and water. This is particularly necessary when taking a finishing cut. Paraffin is a good lubricant for aluminium, although turpentine is better. Cast steel may be lubricated with engine oil. Cast iron, brass, copper and gun-metal are turned without any lubricant.

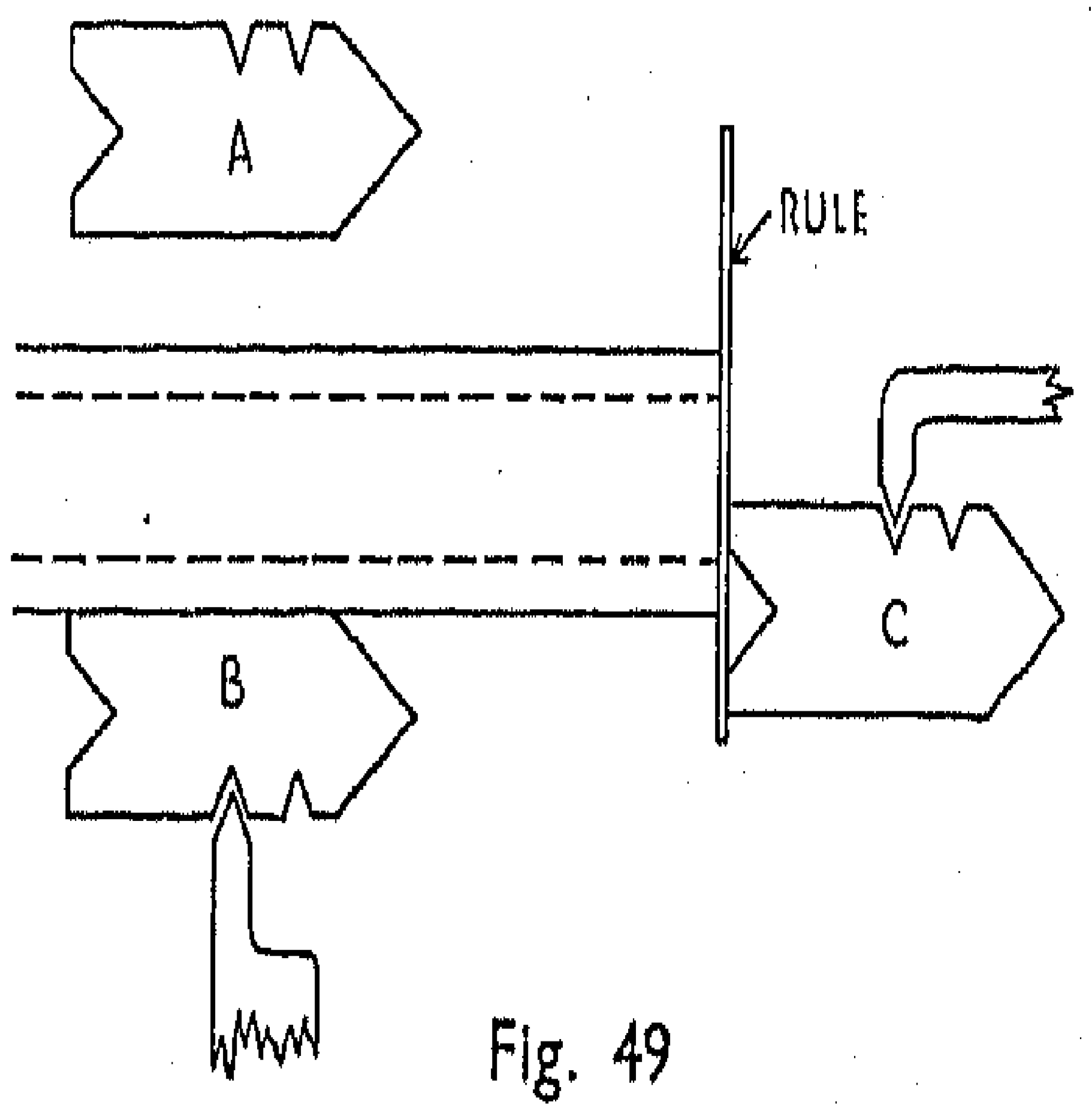


Fig. 49

FILES AND SCRAPERS

Files are as important to the metal-worker as the plane is to the carpenter, for just as a woodworker first uses a saw for cutting the material roughly to shape and then planes the wood to the desired size, so the metal-worker first applies a chisel or a hacksaw for roughing out the metal and then uses the file to finish the work.

Files are made of hardened cast steel, and their faces are provided with cutting teeth as shown in Fig. 1. They are used essentially for reducing a piece of metal to a smaller size, smoothing down uneven surfaces, and for giving a smooth finish.

Files are generally classified by their shape, cut, and the degree of coarseness of the teeth.

To go into details of every kind of file is unnecessary here. We will therefore strictly confine our attention to those tools you are likely to need.

Fig. 2 illustrates a few of the most useful shapes of files, and the kind of work on which they are intended to be used is as follows:

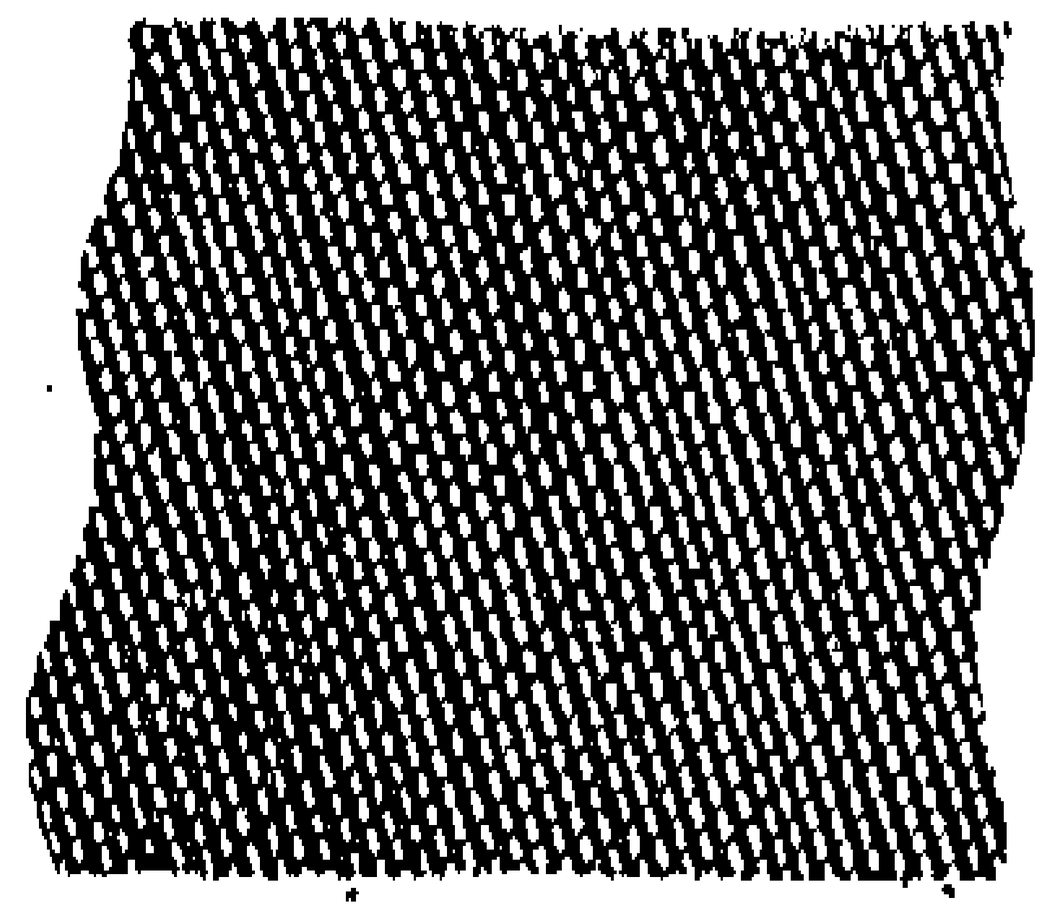


Fig. 1

A.—The hand or parallel file. This is used for all kinds of flat work such as slots and shoulders which are required to be filed parallel. This type of file usually has one plain edge without teeth—known as a safety edge—the object being to allow the teeth to be used in a corner without risk of damaging the adjacent surface.

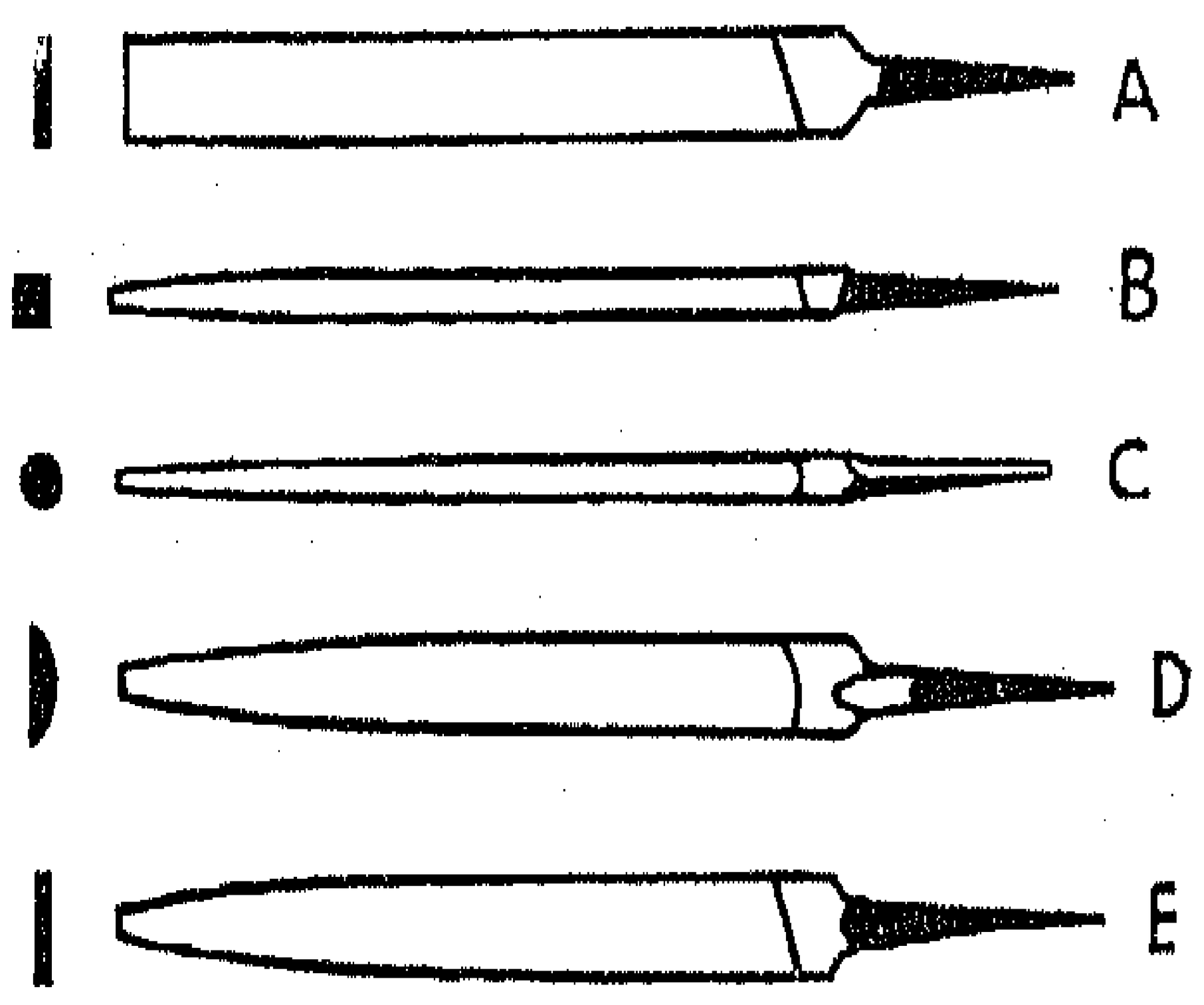


Fig. 2

B.—The square file is used for filing square holes, slots, and between narrow surfaces.

C.—The round file is used for enlarging holes and rounding slots, etc.

D.—The half-round file is employed for working on concave or hollow surfaces, enlarging holes, etc.

E.—The flat file with bellied sides is used principally for roughing out flat work.

All the above-mentioned tools, with the exception of the hand or parallel file, taper towards their ends; a parallel portion is provided, however, near the tang or handle end.

A file may be either single cut or double cut as in Fig. 3, at A and B.

In the former the teeth are made at an angle across the face in one direction only, while in the double-cut file an extra set of teeth is formed across the other, the result being a surface consisting of sharp points.

Single-cut Files are used mostly for working the softer metals such as brass, copper, lead, etc. For general work and filing iron and steel the double-cut file is the correct tool to use.

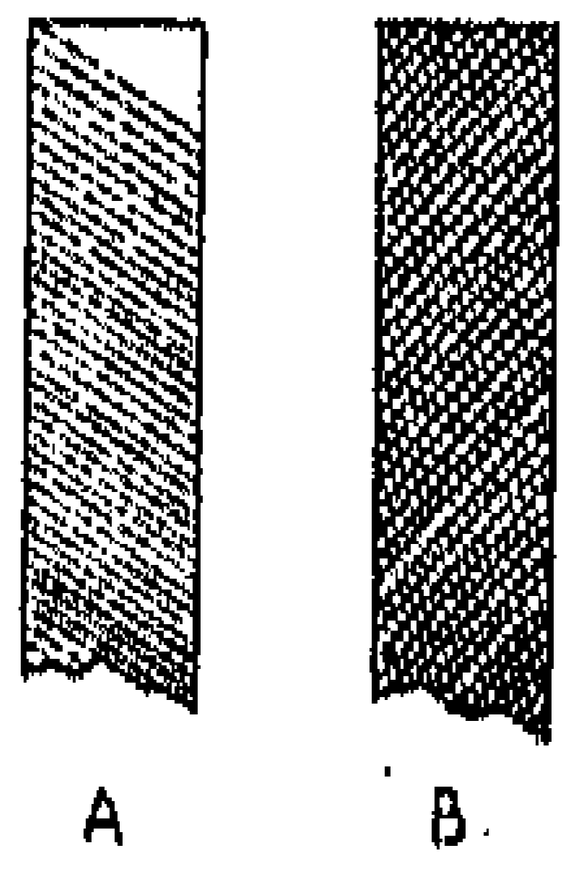


Fig. 3

With regard to the degree of coarseness or fineness of the teeth, this must be determined by the nature of the work in hand. If it is desired to remove a large quantity of metal, a large rough file should be used, while if only a finish is required, then a smooth file is the tool to use.

When a new file is brought into operation it should first be used on brass or gun-metal; it can then be used effectively on steel and wrought iron, but a file that has been used on steel will not cut brass efficiently.

Never use a new file to remove the scale off castings. Do this with an old file, and when the "skin" has been removed a new file may be brought into action.

The Art of Filing correctly requires a considerable amount of skill which can only be obtained by practice. You will find it by no means a simple operation to file a surface perfectly flat, the tendency being to produce a more or less rounded surface.

For the purpose of explaining the process of filing let us take as a simple example a piece of mild steel 2 in. × 1 in. × 1 in. which has to be reduced in size to 2 in. × $\frac{7}{8}$ in. × $\frac{7}{8}$ in.

After having carefully marked out the material by means of a scriber and centre-punch (as indicated in Fig. 4), fasten the work securely in the vice with the marking-off lines just above the top of the jaws and about level with the elbow. Take a rough file and grasp the handle—a file should never be used without a handle—with the right hand, keeping the knuckles downwards; grip the opposite end of the tool with all fingers of the left hand as shown in Fig. 5, which indicates the correct way to handle a file.

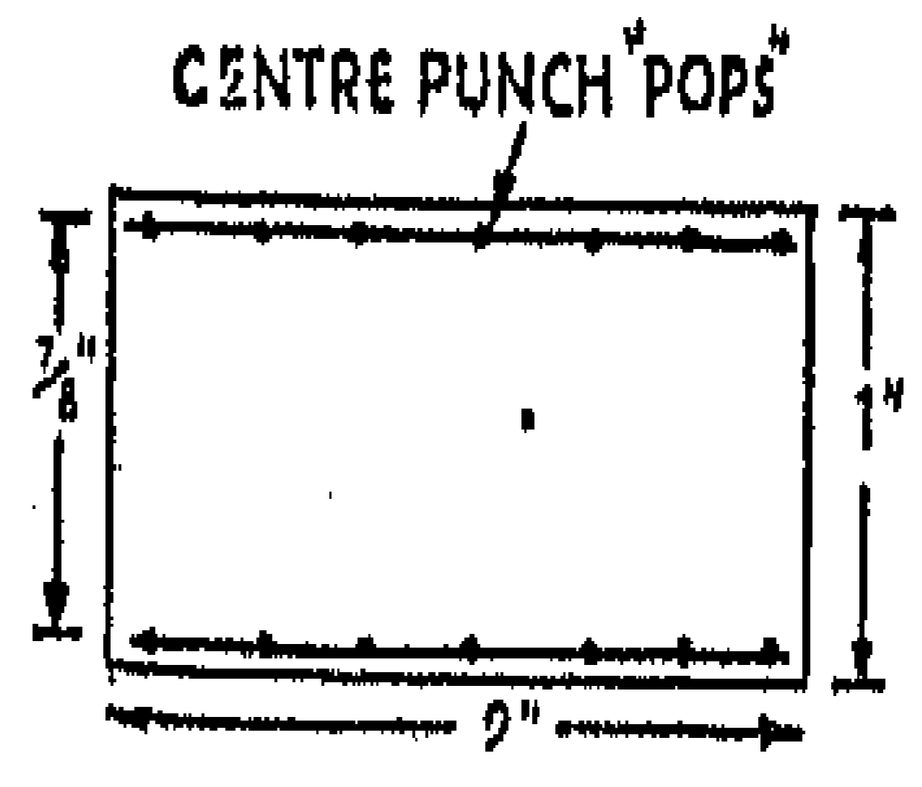


Fig. 4

Place the end of the file in a horizontal position upon the surface of the work, and push it forward, applying pressure with the left hand and gradually transferring the pressure to the right hand as the file advances towards the end of its stroke. This completes the cutting stroke, and it is well to remember that a file only cuts on the forward stroke as the teeth are shaped to cut in this direction. Failure to observe this will result in a ruined file. Now relieve the pressure and draw the file back over the work to its original position. Any pressure exerted on this stroke will only wear the teeth out. Continue the rough filing, as it is called, until nearly all the waste metal is removed on both faces, leaving about $\frac{1}{64}$ in. clear above the marking-off lines for finishing purposes. Take a second-cut (medium teeth) file and remove the marks left in the work by the rough file, taking care that you do not file below the marking-off lines, and then finish off dead to size with a smooth file by drawing it across the work. This process is known as drawfiling, an illustration of which appears in Fig. 6. If any clogging of the teeth takes place when using the second-cut and smooth files, apply some ordinary chalk to the surface of the tool. This will usually have the desired effect.

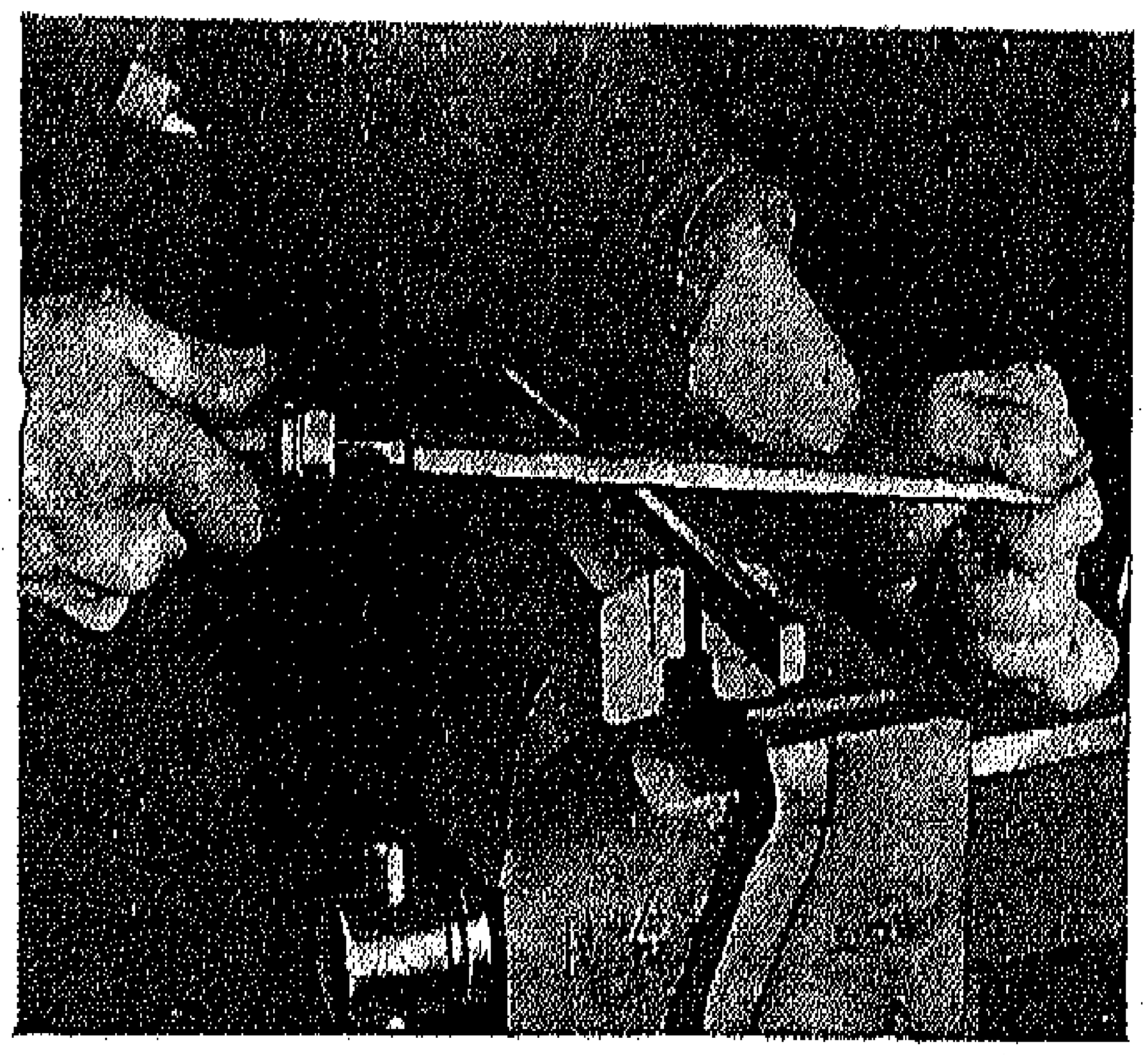


Fig. 5

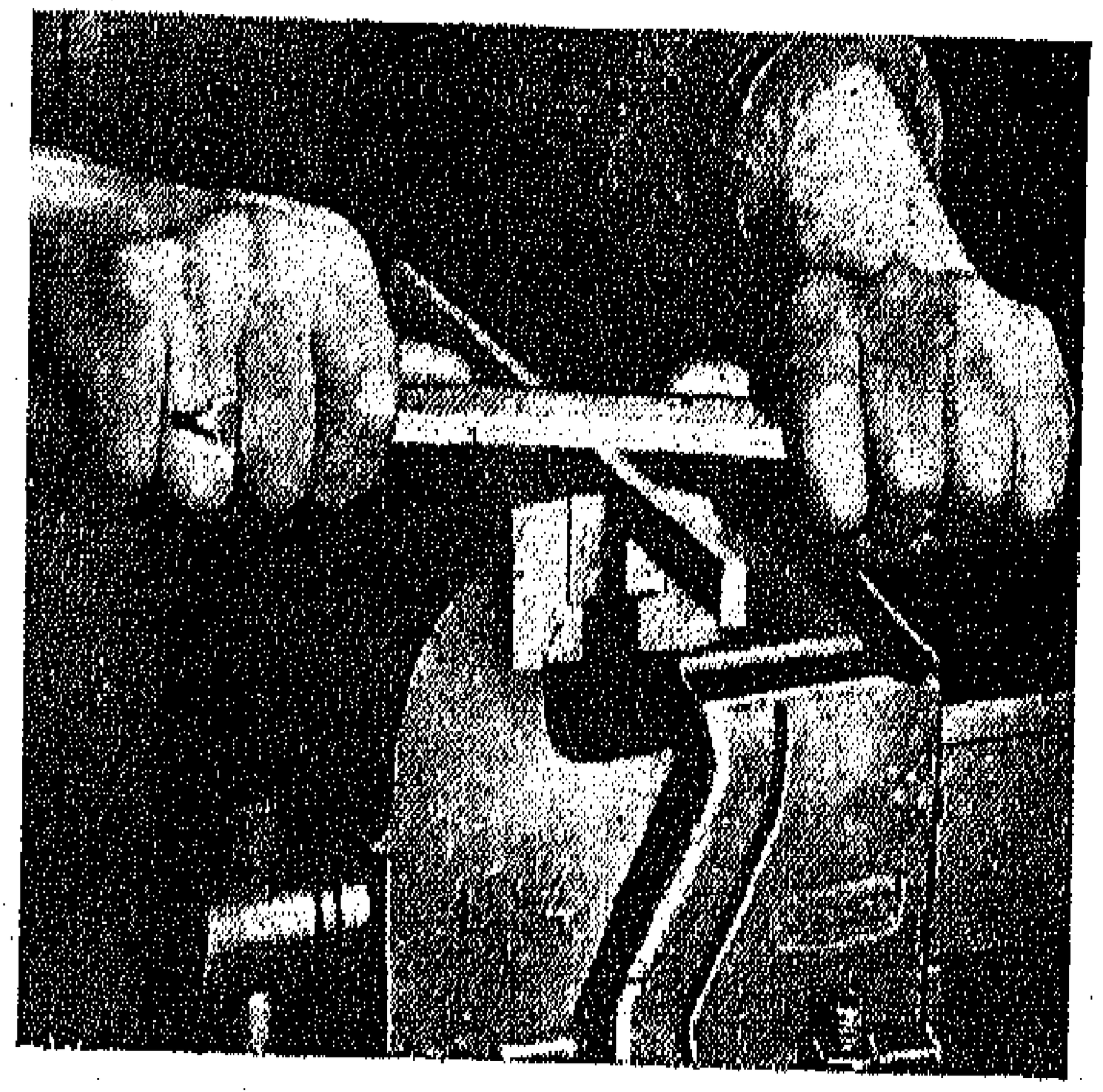


Fig. 6

If you have marked off the work and used the files correctly you will find that one-half of each centre-pop has been removed while the other half remains. To complete the work, polish it with fine emery cloth wrapped round a square block of hardwood and apply a few drops of oil to the emery cloth.

Scraping is resorted to in cases where a higher degree of accuracy and finish is required than that produced by filing, etc. The process consists in removing minute amounts of metal with a tool called a scraper.

Scraping is very skilled work. The method of handling the tool itself can be quickly learned, but the actual scraping, that is, the removal of the right amount of metal at the right place, needs great care and experience. The latter can be obtained more quickly if the principles underlying the operation are thoroughly grasped at the start.

Fig. 7 shows a handy type of scraper suitable for treating bearings of motor-car and gas-engine crankshafts as well as big ends of connecting rods. It can also be used for flat work.

Such a scraper can be easily made from an old half-round file. It should be annealed by heating it to a bright red colour and allowing it to cool in the ashes of the fire while the fire goes out. When cold, it should be roughly filed, to remove all tool-marks, for a distance of 2 or 3 in. from the working end. The remaining teeth need not be quite so fully removed, but sufficiently to enable the tool to be held comfortably without roughing the hand. The blade should then be turned up slightly at the end as shown, and ground slightly convex on the flat side.

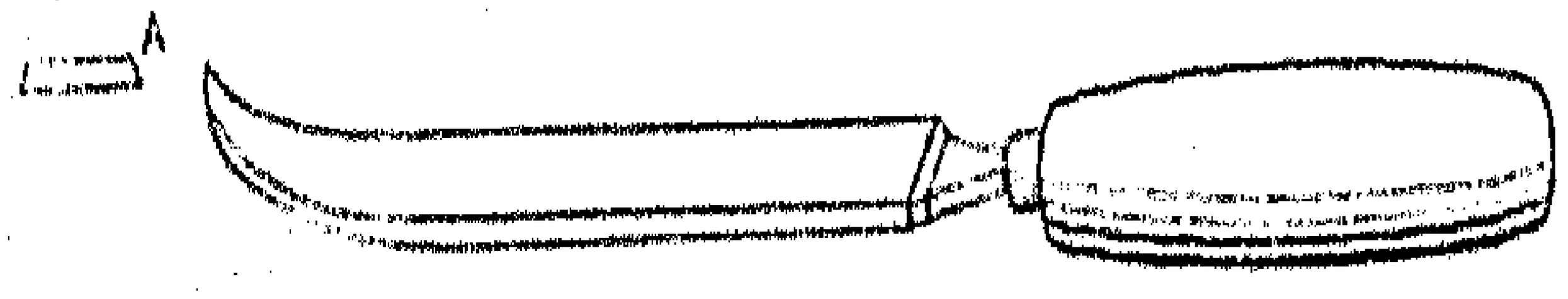


Fig. 7

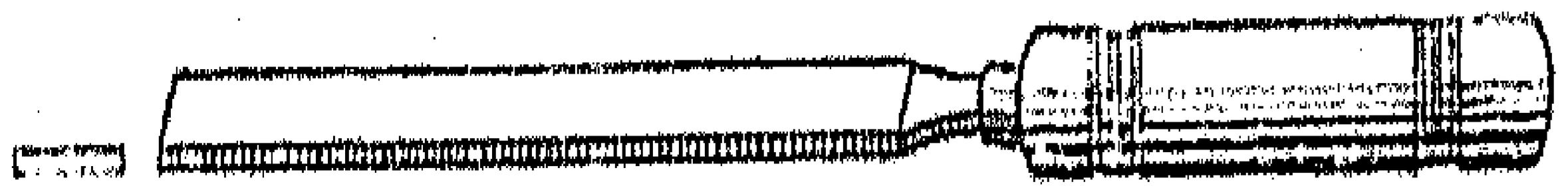


Fig. 9

The scraper must now be hardened and tempered by heating it to a full red colour, as before, and plunging it vertically into a pail of swirling, clean, cold water in which a handful of salt has been dissolved. This will make the tool dead hard and very brittle. It should then be cleaned bright and heated with a blow-lamp and tempered. The heat should not be applied directly to the cutting end but at a distance of about 3 or 4 in. from it.

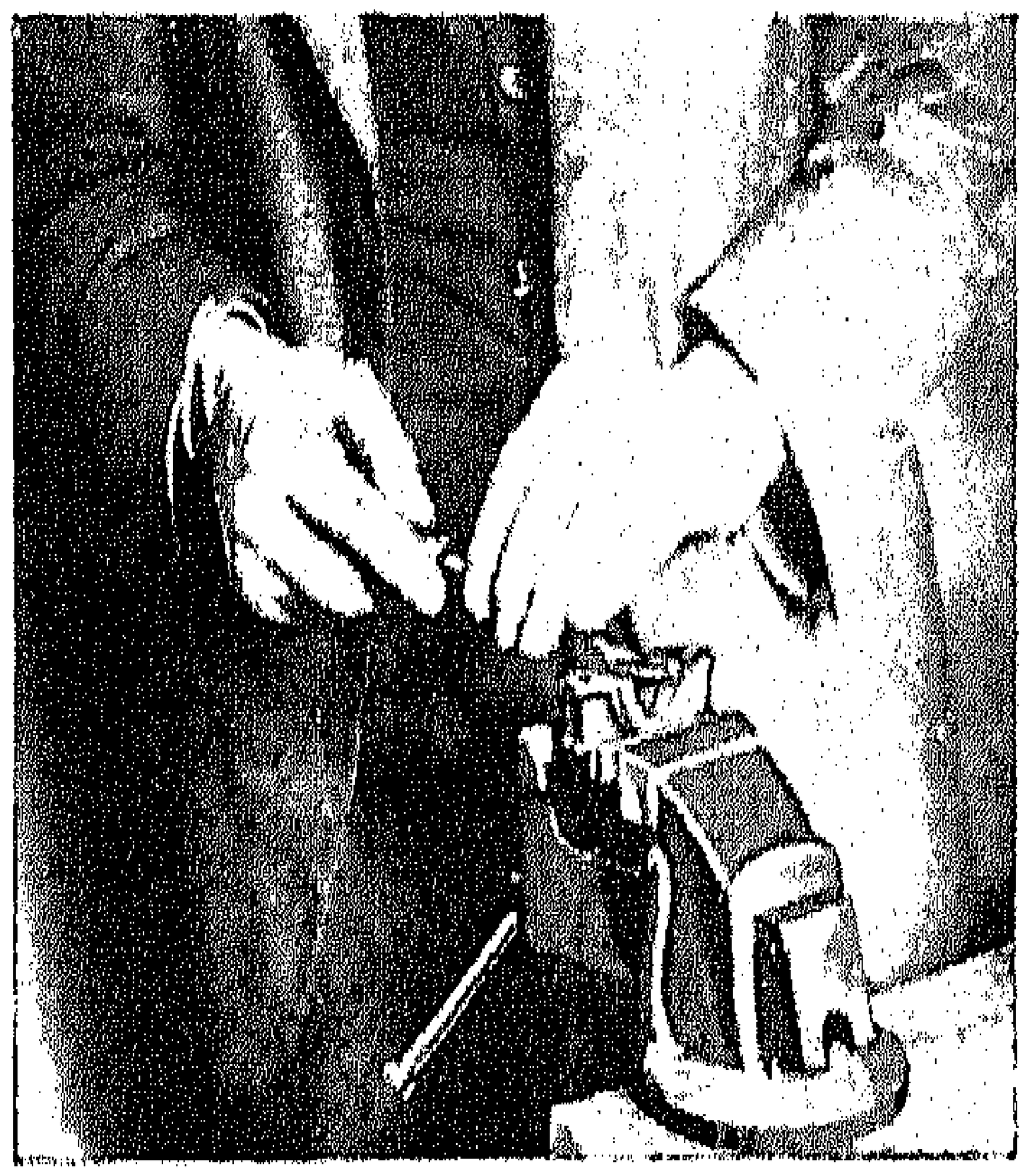


Fig. 8

To use the tool it should be held in the manner indicated in Fig. 8. The right hand keeps the tool steady but exercises little movement, while the fingers and thumb of the left hand hold the scraper near the work. The tool is then drawn steadily towards the operator, at the same time exerting slight pressure on the work to enable the cutting-edge actually to cut the metal, which should come off in minute curls.

The Flat Scraper (Fig. 9) can be made of a wide, flat file. The forward edge is used and in this case the tool is pushed away from the operator. The left hand is used for applying the pressure—as before—and the right hand for holding the tool at the correct angle and propelling it along the work. This tool has flat sides and edges and the working end is ground square with the sides and edges.

When scraping a bearing the working surface should be lightly smeared with a mixture of the finest red lead moistened with linseed oil. The journal should then be laid in the bearing and the shaft slowly revolved. The places where the journal touches the bearing will be clearly indicated by the "marking" (red lead) being rubbed. These are the places to be very lightly scraped in short, narrow "scrapes." When the high places have been removed, the remaining marking should be rubbed off, a fresh supply of red lead applied, and the journal revolved in the bearing, as before. On removing the journal it will be seen that the shaft has marked a larger surface of the bearing than previously, and this area should be scraped, and so on until the journal marks the whole of the surface when rotated. When this occurs the bearing is said to be "fitted," and having reached that stage it can be cleaned and assembled. The same procedure is followed in scraping flat surfaces such as the bed of a lathe, the slides of a slide-rest, or the face and bed of a steam engine slide-valve.

One part is marked and the other gently rubbed on it. The high places indicated are then scraped and the process repeated till a flat smooth surface in contact all over is produced.

For very fine work, finely-ground lampblack can be used instead of red lead, and for extremely fine work Prussian blue scholar's oil colour supplied in collapsible tubes may be used.

The vital point about scraping is to remove only a small quantity of metal at a time between subsequent markings, otherwise a large surface may have to be scraped to get down to a part scraped too low. In the case of scraping bearings, always make sure that the journal of the shaft is quite smooth and clean, and at each trial marking, scrape every spot which shows high, otherwise the next marking will be deceptive.

MEASURING INSTRUMENTS

As many branches of metal-work, such as turning and fitting, require a very high degree of accuracy, it is obvious that measuring devices, such as rules and ordinary simple callipers, are out of the question, and it is therefore necessary to employ instruments of a much finer degree of precision.

The instruments commonly used for measuring these minute fractions are known as sliding-gauges and micrometers.

It is unnecessary to go into details of ordinary simple callipers here as these measuring instruments are dealt with in the section on METAL-TURNING, but before going into details of vernier gauges and micrometers it may be an advantage to mention one or two instruments which, strictly speaking, do not come within the category of precision instruments, but are nevertheless extremely useful.

The first of these is shown at A in Fig. 1, which illustrates a registering calliper. It is useful, where extreme accuracy is not required, because the size of the work measured between the legs is indicated on a divided scale engraved on a quadrant attached to one of the legs. The other leg carries a pointer which indicates on the scale the measurement taken. It will be seen that the scale has a zero mark in the centre of the quadrant. This enables the index to swing on either side of the zero mark, depending upon whether the legs are being used upon external or internal work.

The illustration at B shows another special type of calliper which is very handy, as the legs can be finely adjusted by means of a milled screw. It is also fitted with a detachable leg, which allows measurements to be taken as shown in the drawing, where ordinary callipers could not be used.

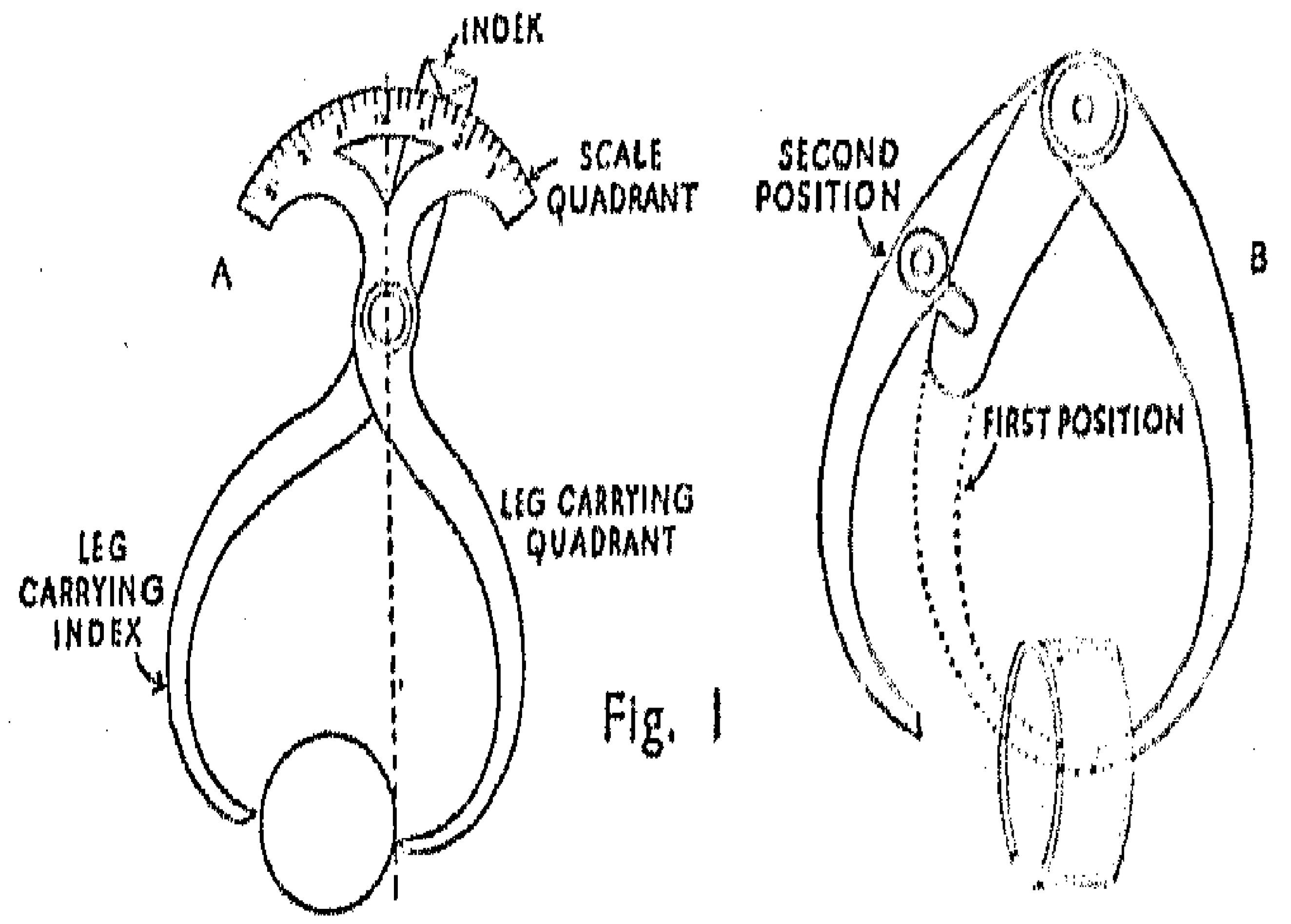


Fig. 1

A Simple Form of Slide-gauge, where the object to be measured is placed between the jaws, is pictured at A in Fig. 2. It consists of a thin metal bar or stock having a projecting piece at the end which forms the fixed jaw. A suitable scale either in inches and fractions of an inch, or a metric scale, is engraved on the bar. The sliding jaw fits over the stock and is provided with a thin edge which moves over the graduated scale, while an adjusting screw allows the jaw to be locked in position when a measurement has been taken.

To take a measurement with a slide-gauge, all that is necessary is to place the object on the fixed jaw and slide the other jaw up to the work until the jaw just touches it. The locking screw is then tightened to keep the jaw in position and the dimension required is read off the scale where the thin edge coincides with a figure on the scale. An illustration of the method adopted is shown in Fig. 3.

The type of slide-gauge shown at A in Fig. 2 can only be used for determining external measurements.

A better type of slide-gauge, which can be used for external and internal measurements, is shown at B in Fig. 2. In this instrument small projections are provided on the ends of the jaws to allow them to enter the hole to be measured. Two index marks are engraved on the sliding jaw for indicating outside and inside measurements respectively, the extra index being necessary to allow for the thickness of the projections on the jaws. It will be observed that inside measurements of under ¼ in. cannot be taken with this instrument.

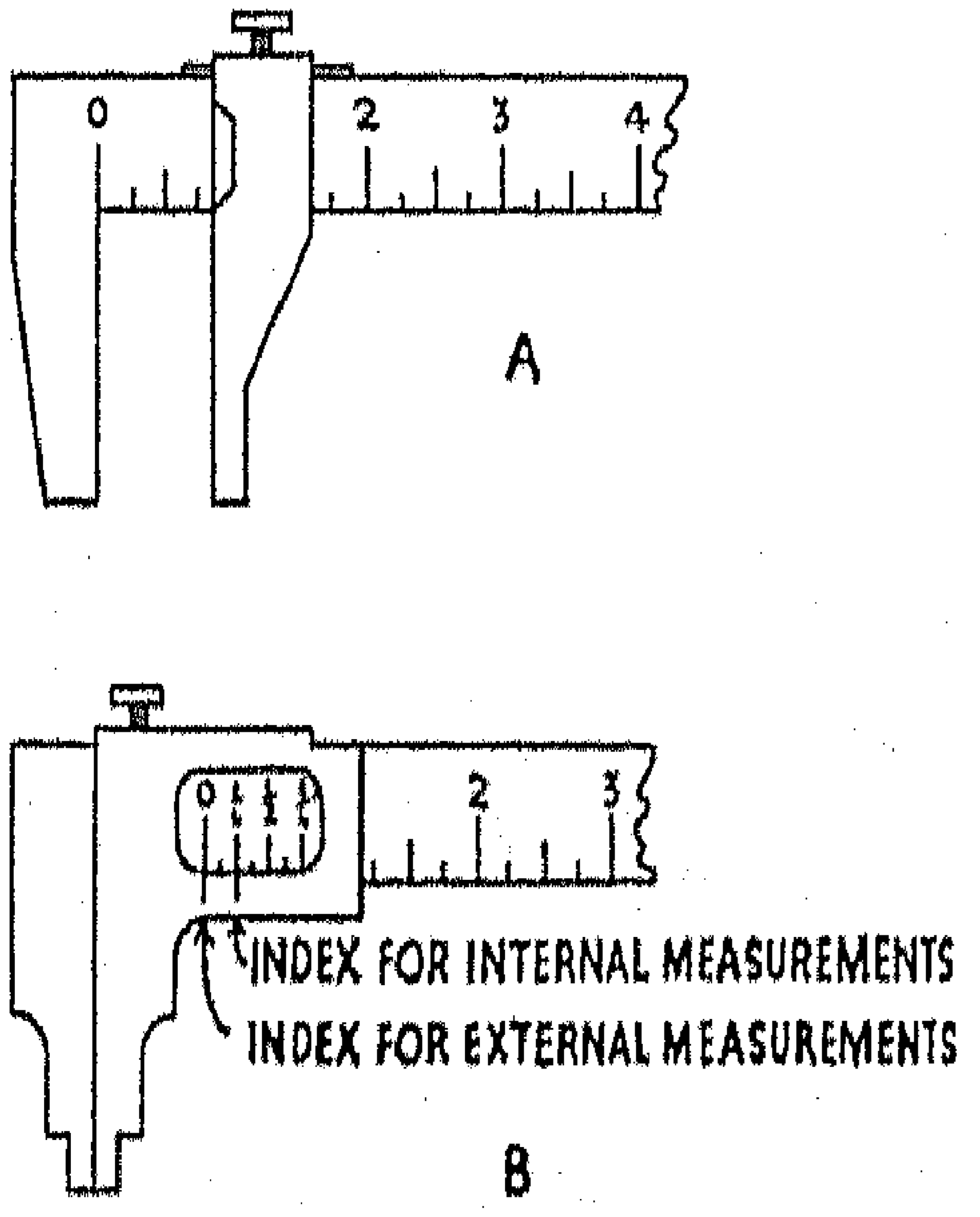

0
2
3
4
A
0
2
3
INDEX FOR INTERNAL MEASUREMENTS
INDEX FOR EXTERNAL MEASUREMENTS
B

Fig. 2

We now come to those instruments

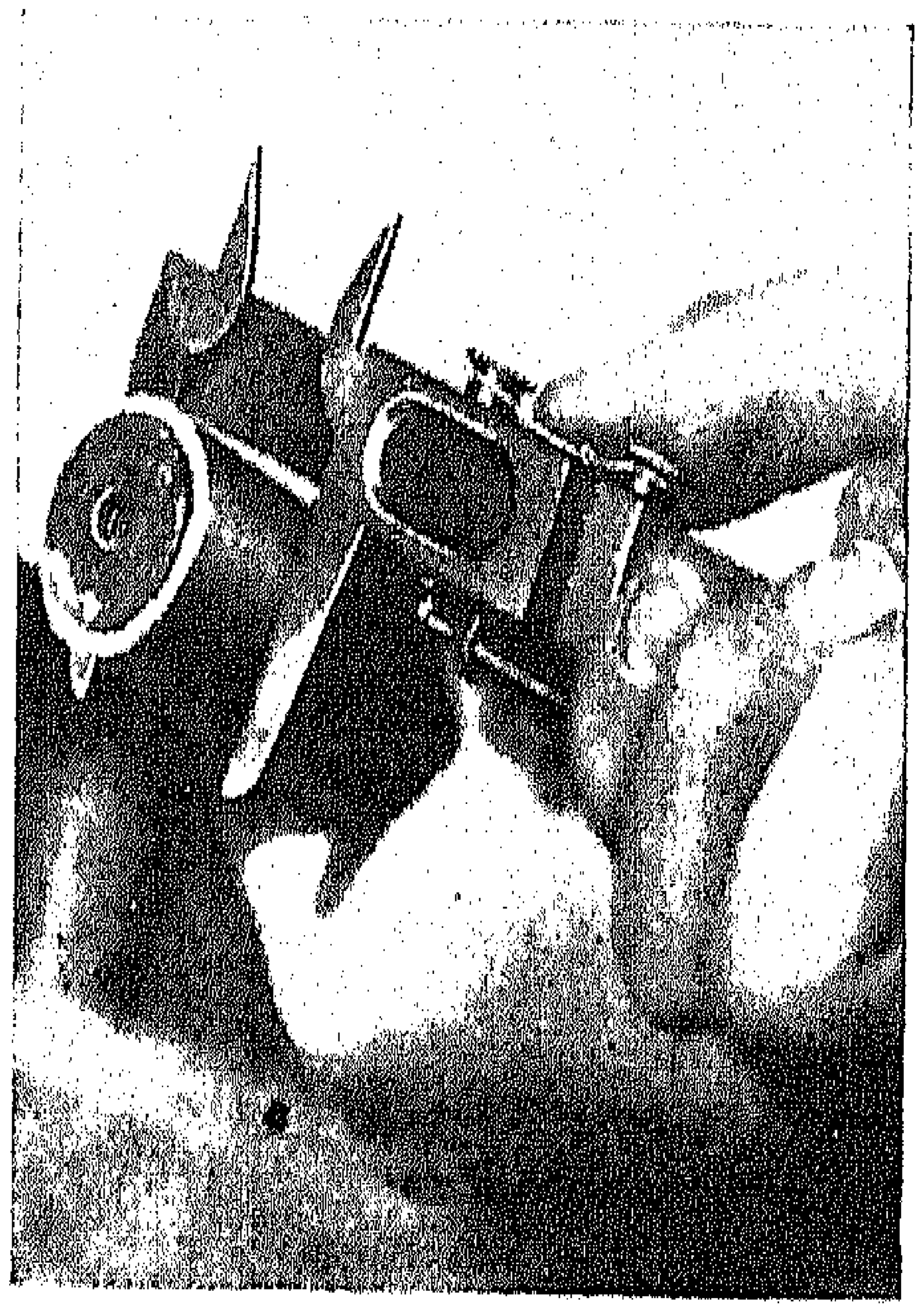


Fig. 3

which are commonly used for taking measurements as small as $\frac{1}{1000}$ of an inch, namely the vernier calliper and the micrometer.

Fig. 4 shows an illustration of the business end of a vernier calliper, with the bar scale A and the vernier scale B clearly indicated.

On the bar of this instrument is a scale of inches, each of which is subdivided into ten parts and each tenth into four parts, thus making a total of forty divisions per inch; thus each division on the scale represents $\frac{1}{40}$ in., which in decimal notation is ·025 in. On the moving jaw is a vernier scale which is exactly equal in length to twenty-four bar divisions but is divided into twenty-five equal parts. If the end lines of each scale exactly coincide, the first division on B will fall short of the first on A by $\frac{1}{25}$ of $\frac{1}{40}$, which equals $\frac{1}{1000}$ or ·001, the second will fall short of the second on the bar scale by ·002 and so on. If the vernier is moved to the right until the fifth sub-division agrees with the first on the scale, the vernier has moved ·005. No other pairs of gradations then coincide.

To use the vernier, first note the number of inches, tenths and fortieths of an inch—the zero mark on the vernier is from the zero mark on the bar—then note the number of division lines on the vernier which exactly coincides with some division line on the bar scale. This will indicate the number of thousandths of an inch to be added to the distance read on the scale of the bar.

To make this clear let us take an example.

Assuming that the 0 or zero mark on the vernier has moved through two-inch divisions, three-tenth divisions, and three-fortieth divisions on the bar scale and that the line seven on the vernier coincides with a division line on the scale. The total will then be:

$$2 + \cdot 3 + \cdot 075 + \cdot 007 = 2\cdot 382 \text{ in.}$$

An ordinary screw micrometer callipers,

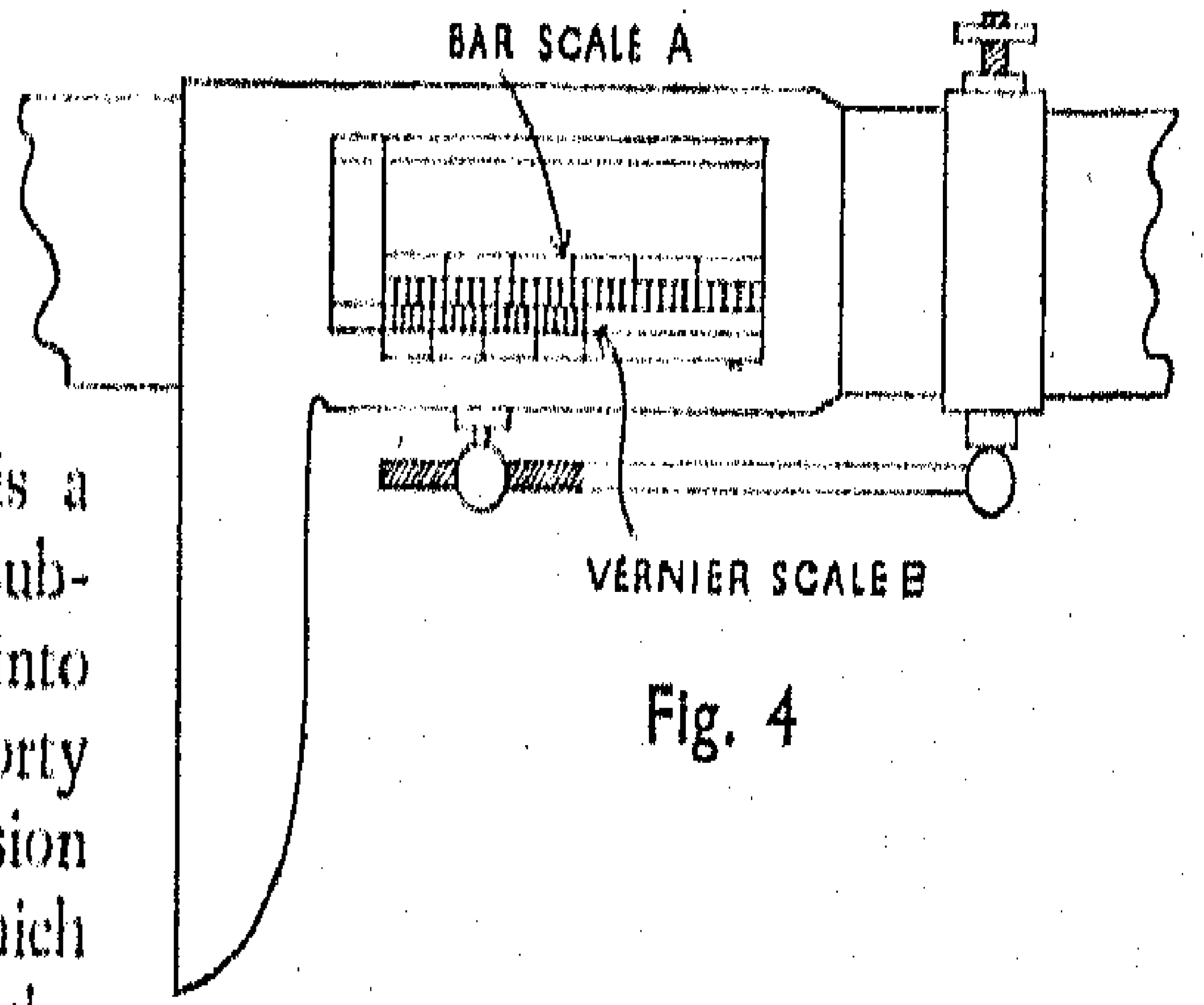


Fig. 4

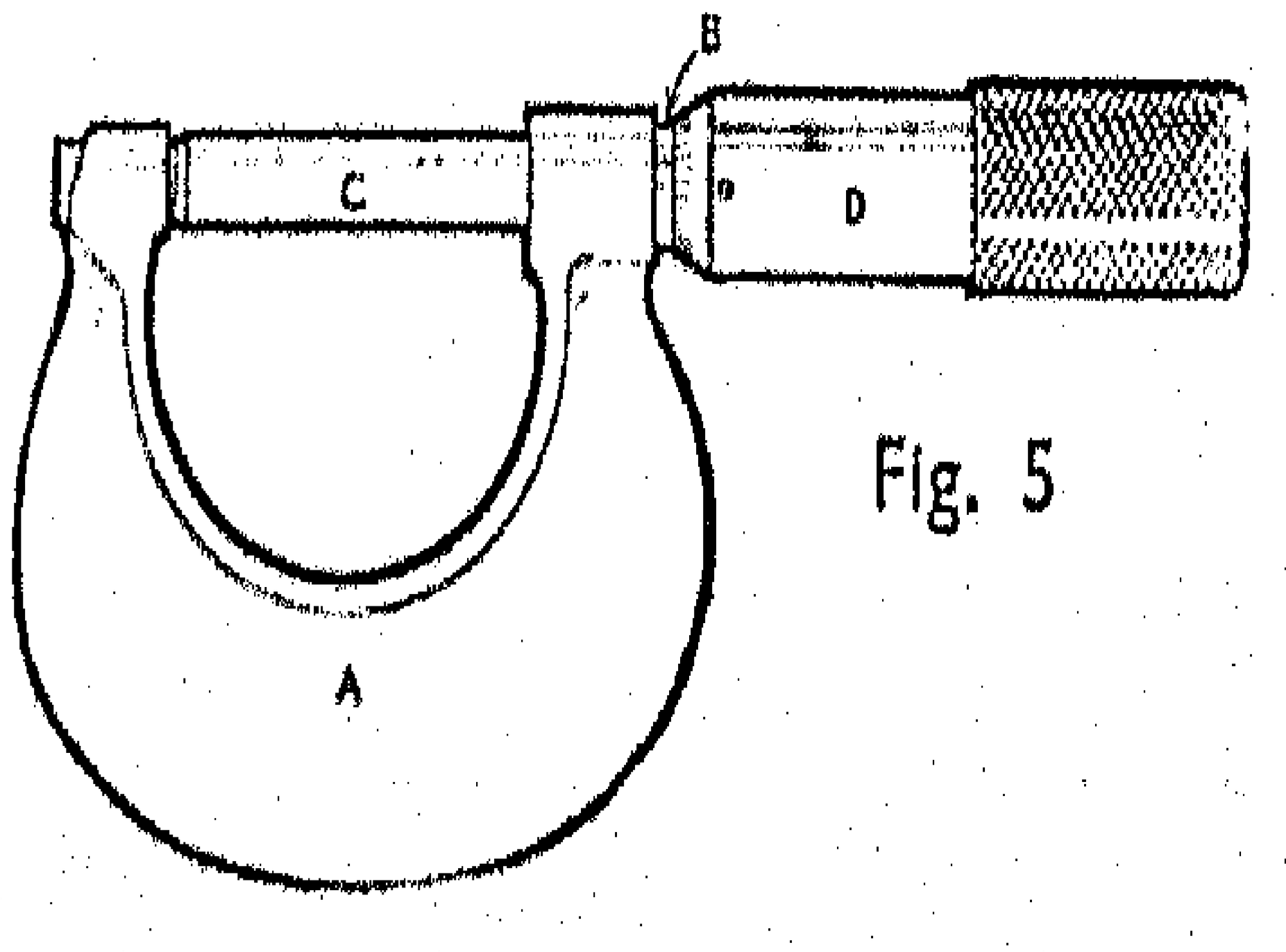


Fig. 5

or micrometer as it is usually called, is shown in Fig. 5.

There are many types of micrometers, some fitted with a locking device to lock the spindle when a measurement has been taken, others fitted with a ratchet for gauging the correct pressure between the jaws; but of whatever type the micrometer may be they all work on the same principle, based on the screw-thread.

If a screw of, say, eight threads to the inch is fitted into a fixed nut and rotated through one revolution, the amount of the advance of the screw will be equal to the pitch of the thread, viz. $\frac{1}{8}$ in. Similarly, if the screw is rotated through one-half a revolution then the travel of the screw will only be one-half the pitch, or $\frac{1}{16}$ in., and if rotated one-tenth of a revolution the movement of the screw will be $\frac{1}{10}$ of $\frac{1}{8}=\frac{1}{80}$ in. It will thus be seen that the screw-thread offers a ready means of making fine measurements.

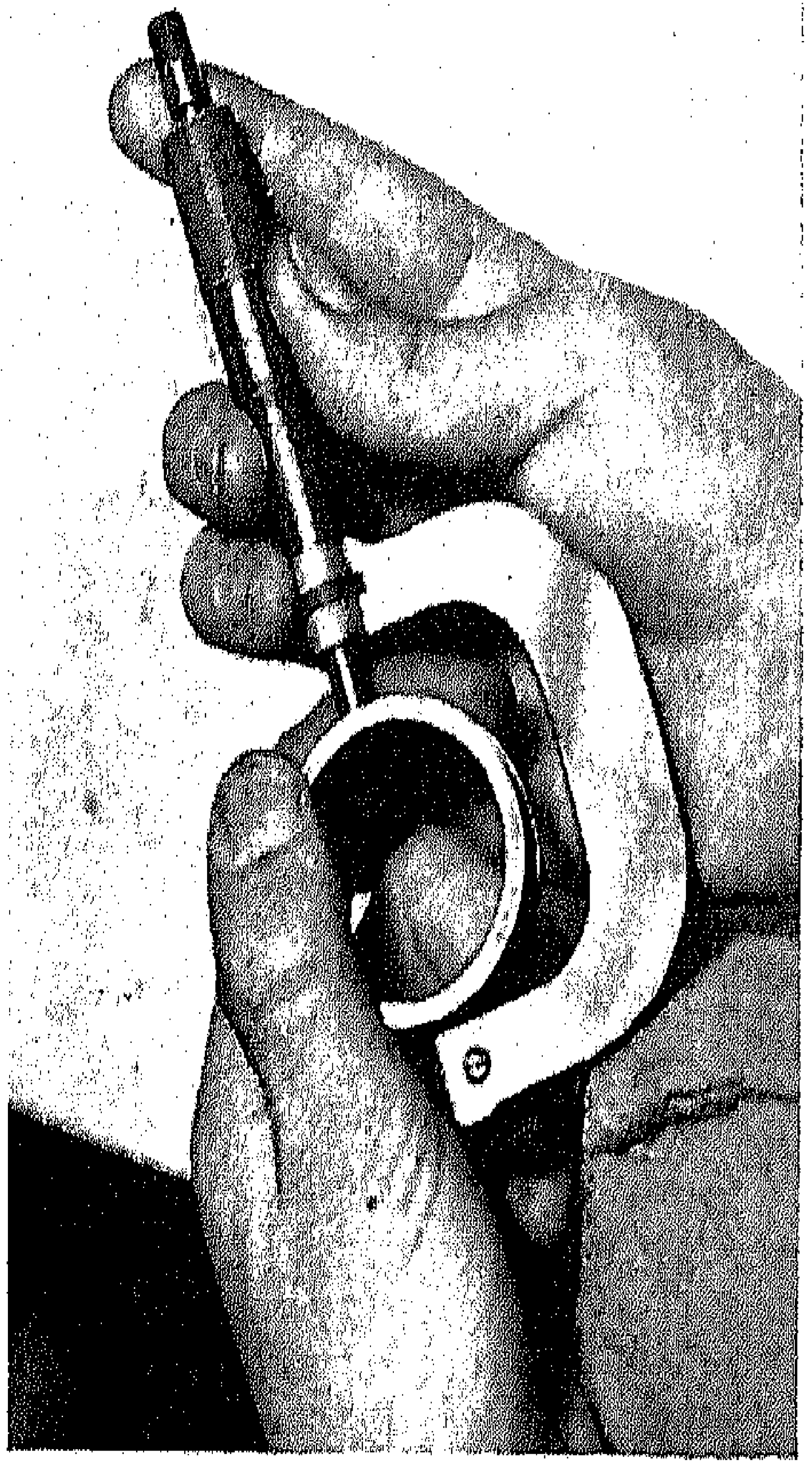


Fig. 6

In Fig. 5, A represents the frame, in which is incorporated the barrel B. This is internally threaded for a portion of its length with threads of a pitch of forty to the inch. The partially threaded spindle C is attached to the back end of the hollow sleeve D, which engages with the internal thread in the barrel. The horizontal zero line seen on the barrel is graduated into tenths of an inch which are further sub-divided into quarters, so that every small division is equal to $\frac{1}{40}$ in. The bevelled front edge of the sleeve or thimble is divided into twenty-five equal divisions numbered at 0, 5, 10, 15, 20. When the sleeve is rotated through one revolution, the spindle will move through one scale division or ·025 in. When the jaws are closed the zero mark on the scale should agree with the zero mark on the sleeve. If the sleeve is now twisted in an anti-clockwise direction until the first sleeve division coincides with the zero line on the barrel, the point of the spindle will move away from the anvil $\frac{1}{25}$ of $\frac{1}{40}=\frac{1}{1000}$ of an inch.

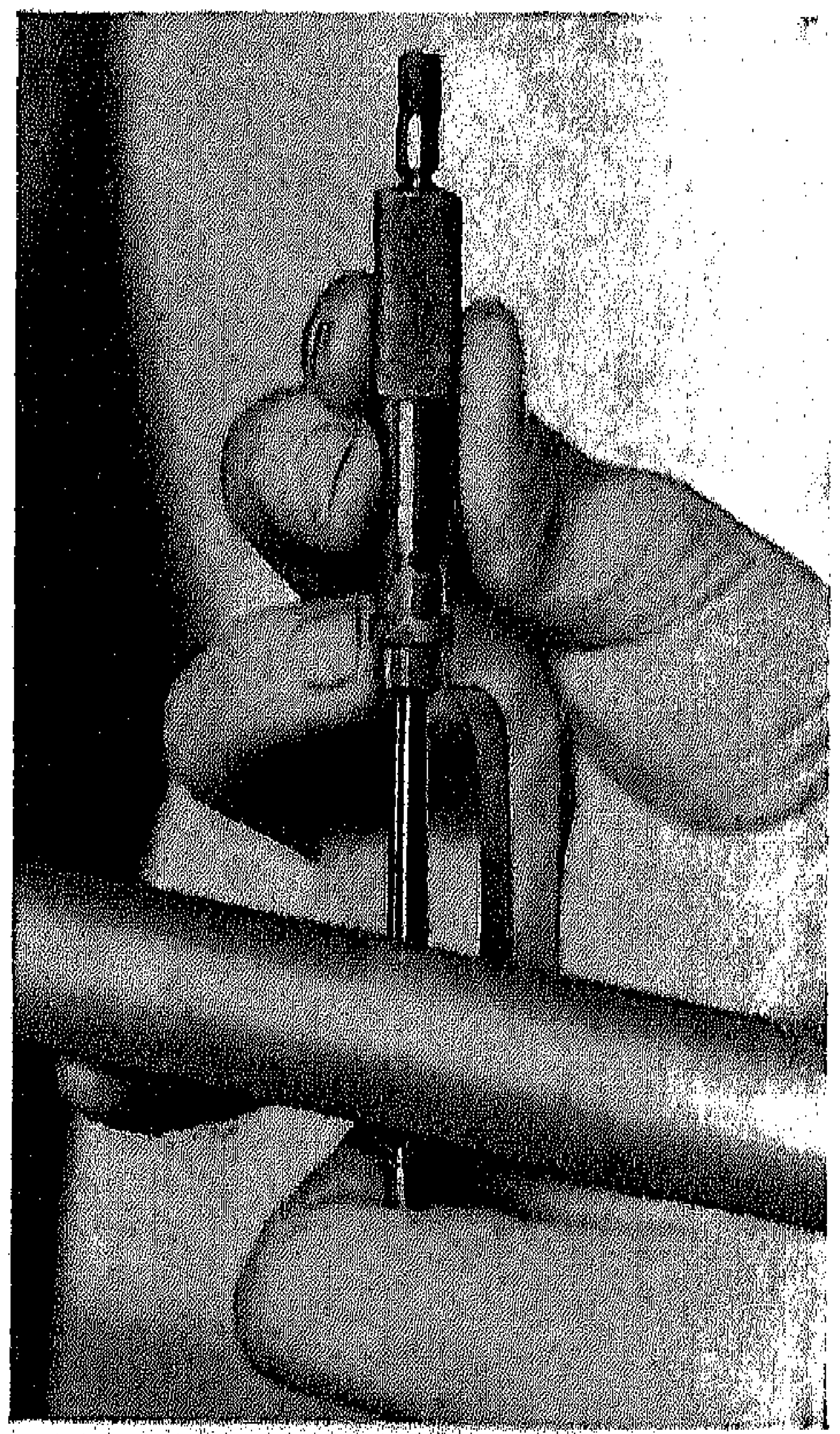


Fig. 7

Fig. 6 shows a convenient method of holding a micrometer when taking the dimensions of an object. Excessive pressure must not be exerted, otherwise a false measurement will result, due to the spring of the instrument. Conversely, if the jaws do not quite touch the work the instrument will record a larger measurement than the object really has. The proper amount of pressure to adopt will soon be acquired by practice.

Fig. 7 shows a micrometer being used to measure the diameter of a piece of work suspended between the centres of a lathe.

DRILLS AND DRILLING

To the uninitiated the mere operation of making a hole in a piece of metal seems but child's play

Admitted that the mechanical operation of drilling is a simple matter, there are other considerations to be taken into account before an accurate hole can be obtained.

A truly accurate-sized hole can only be produced by the proper manipulation of accurate tools.

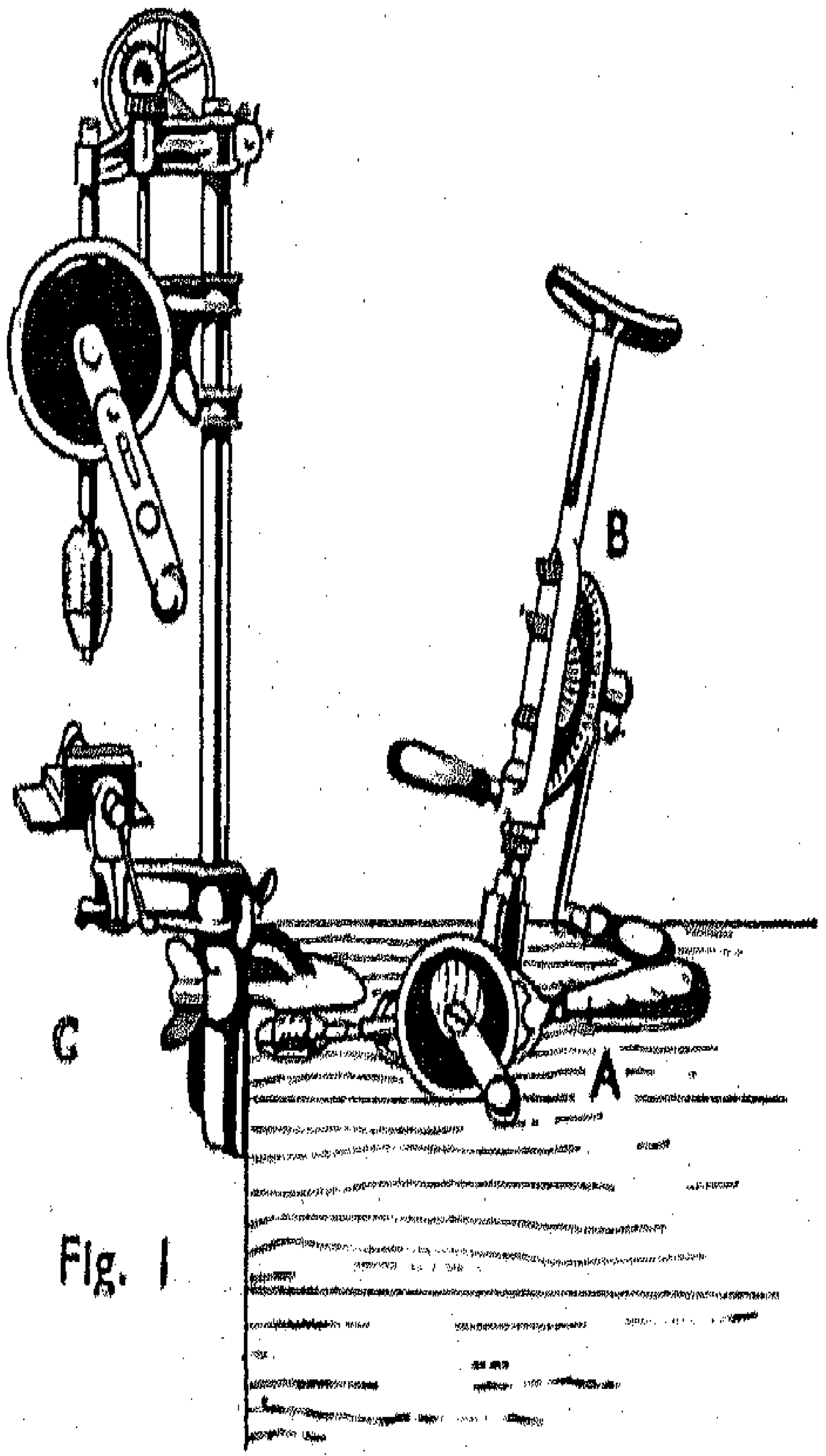


Fig. 1

Small-sized holes are sometimes made by drills rotated either in a small hand-driven drill-stock for holes up to about $\frac{1}{4}$ in. diameter, or for larger-sized holes by a geared breast drill-stock, also driven by hand. A much better method, however, is that obtained by using a drilling machine, which can be driven by hand, foot or mechanical power.

A Hand-driven Hand Drill is shown in Fig. 1 at A, while at B a hand-driven breast drill-stock is indicated. A small drilling machine is shown at C.

Fig. 2, A shows an illustration of a flat drill made from a piece of circular bar steel flattened out at the end and ground to a point. To enable an accurate hole to be made with such a drill the following procedure must be conformed to. The point of the tool must be exactly in the centre of the drill; the two cutting-edges must be equal in length, and they should be backed off to an equal amount to provide the necessary clearance. If one cutting-edge is longer than the other, the drill will make a larger hole than the diameter of the drill. The angle of

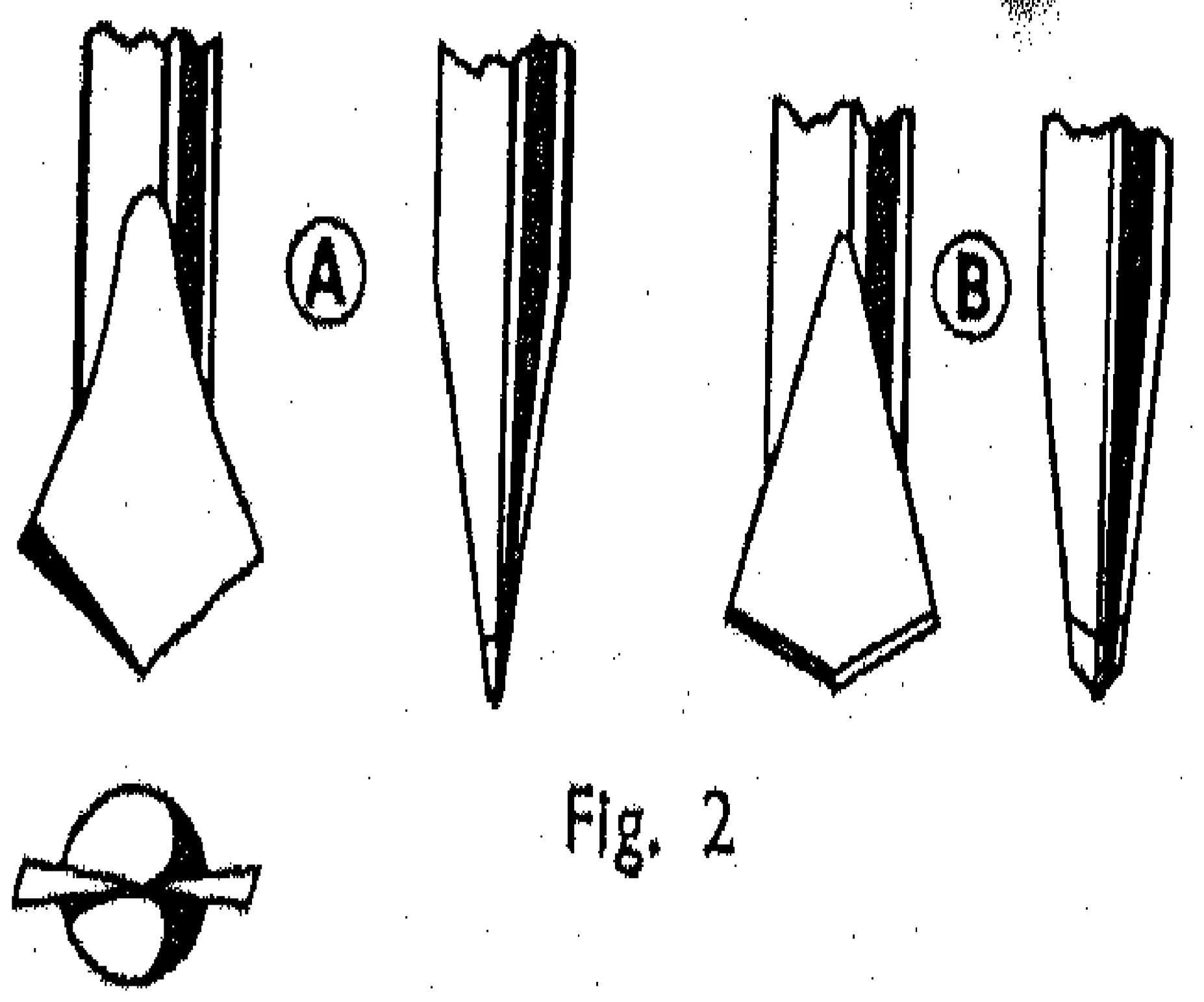


Fig. 2

the cutting-edges of flat drills of this type is 120°; and the angle of clearance about 3°. This type of flat drill can only be revolved in one direction.

Another Type of Flat Drill is shown at B in Fig. 2. Here the cutting-edges are so shaped as to enable them to cut in either direction. Flat drills are not very satisfactory but are useful for rough work where extreme accuracy is not necessary.

The best kind of drill for all general work is the fluted twist-drill represented at A in Fig. 3. This type of drill produces a clean, smooth, accurate hole and clears itself from the cuttings. Twist-drills are not expensive to buy and can be obtained in sizes from ·01 in. up to 3 in. diameter with either parallel or tapered shanks. The twist-drill is made from round steel and has the spiral flutes slightly backed off from the cutting-edges in order to prevent the tool from binding. Twist-drills can be had in either high speed or carbon steel. The former are more expensive, but they are able to remove a given amount of metal at a much higher speed than the latter, as high-speed steel twist-drills do not lose their temper so readily as the carbon variety.

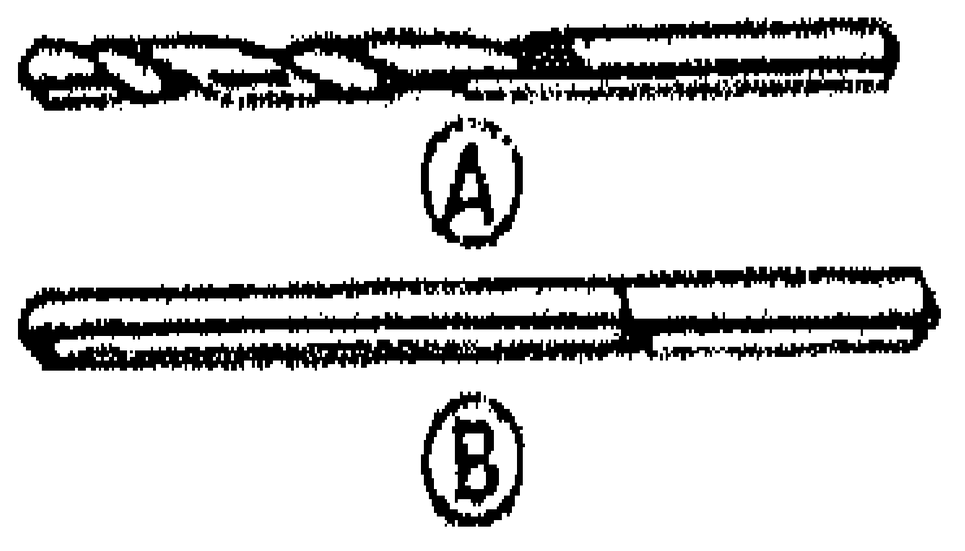


Fig. 3

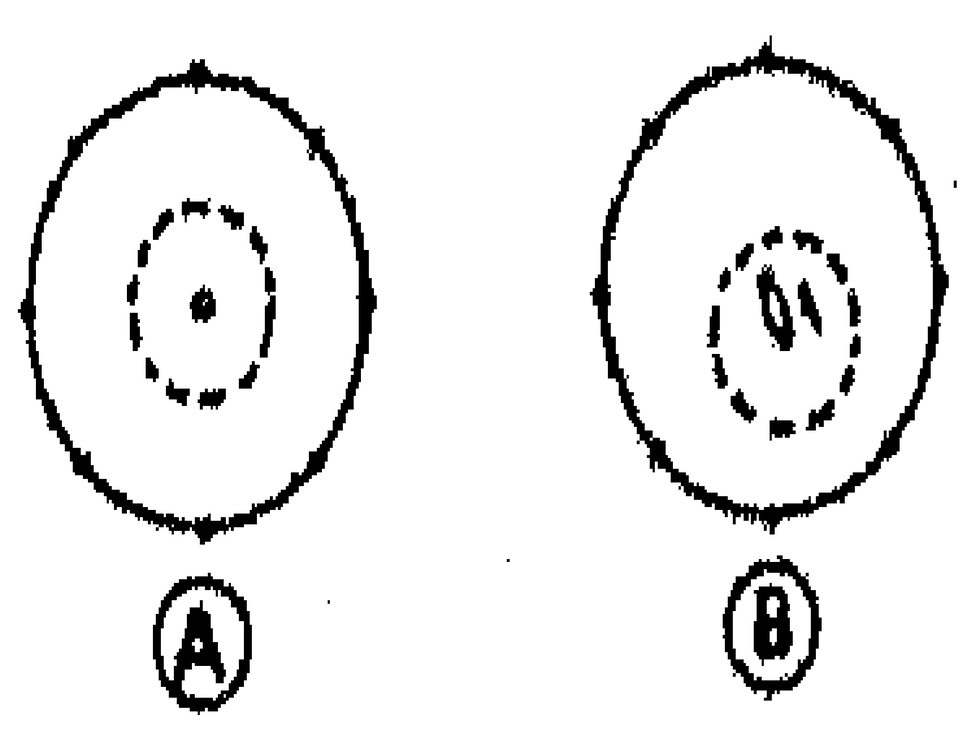


Fig. 4

The usual method of procedure when it is required to drill a hole is first to "mark off" on the surface of the work the size and position of the hole. To do this, make a centre-punch mark in the centre of the material where the hole is to be, and with a pair of compasses describe a circle of the desired diameter, using the "pop" for supporting one leg of the compasses. Next, make several punch-marks on the circle to serve as a guide, as clearly indicated at A in Fig. 4. The work is now ready for the drill. Bring the drill point down on to the corresponding centre-mark in the metal and make a light preliminary cut to ascertain whether the drill is centering itself properly. If the circle cut by the drill is concentric with the marked circle, the drilling may be proceeded with. If this is not so, however, the centre must be drawn over. To do this, make a nick with a small cold chisel in the direction the drill should go, as shown in the sketch at B in Fig. 4. Make another test with the drill and repeat the foregoing operation if necessary, remembering that once the body of the drill enters the metal it is not possible to correct an error.

When comparatively large holes have to be drilled it is good practice first to bore a hole of a smaller diameter—about one quarter the size of the large diameter will do—to act as pilot. This will not only take the strain off the point of the large drill but will also save a large amount of power in driving it.

When Using Twist-drills it is important that they should be driven at the correct cutting speed, which varies according to the nature of the metal being drilled, and that the amount of "feed," or the distance the tool advances per revolution, should not be exceeded. If the cutting speed is exceeded, the corners of the drill will soon be worn away and therefore rendered useless. Excess of speed is generally indicated by a squeaky noise, and excessive speed, too, will be almost sure to result in a broken drill.

The following table of approximate speeds and feeds will serve as a guide when carbon steel drills are used.

Diam. of Drill in ins.	*Revs. per min.*			*Feed per rev.*
	Steel	*Iron*	*Brass*	
$\frac{1}{16}$	1830	2140	3660	$\frac{1}{200}$ in.
$\frac{1}{8}$	915	1070	1830	
$\frac{3}{16}$	610	710	1220	
$\frac{1}{4}$	450	530	915	
$\frac{3}{8}$	300	350	610	$\frac{1}{140}$ in.
$\frac{1}{2}$	225	265	455	
$\frac{3}{4}$	150	175	300	$\frac{1}{110}$ in.
1	110	130	225	$\frac{1}{90}$ in.

The use of high speed steel drills will enable speeds and feeds to be taken of approximately double those given in the above table.

When drilling wrought iron or copper, soap and water may be applied for lubricating purposes; ordinary lubricating oil can be applied when drilling steel. Cast iron and brass do not require any lubricant.

Twist-drills should only be used when in first-class condition. As soon as a drill shows signs of being blunt it should be re-ground.

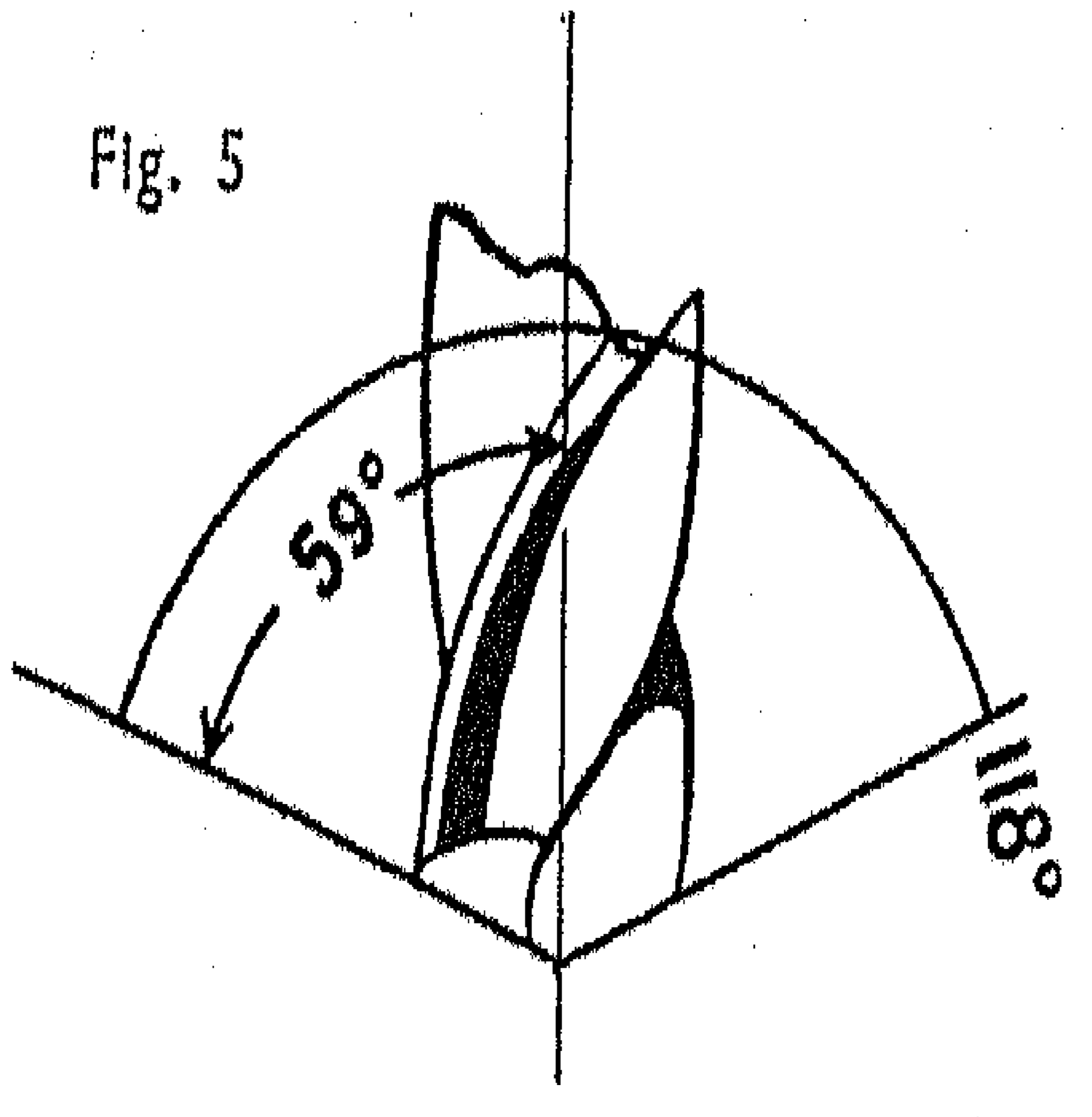


Fig. 5

Fig. 5 shows the cutting-edges of a twist-drill, which should be for ordinary purposes 59° with the central axis of the drill. It is important that both cutting-edges are equal in length and that the point is in line with the axis, otherwise an irregular-sized hole will result. It is also necessary that both cutting-edges are properly backed off or sufficient clearance provided so that only the edges come in contact with the metal. If the surface of the cutting-end of the drill is allowed to come in contact with the metal, it will not cut; on the other hand, if too much clearance is provided, the drill will undoubtedly catch in the metal—with disastrous results.

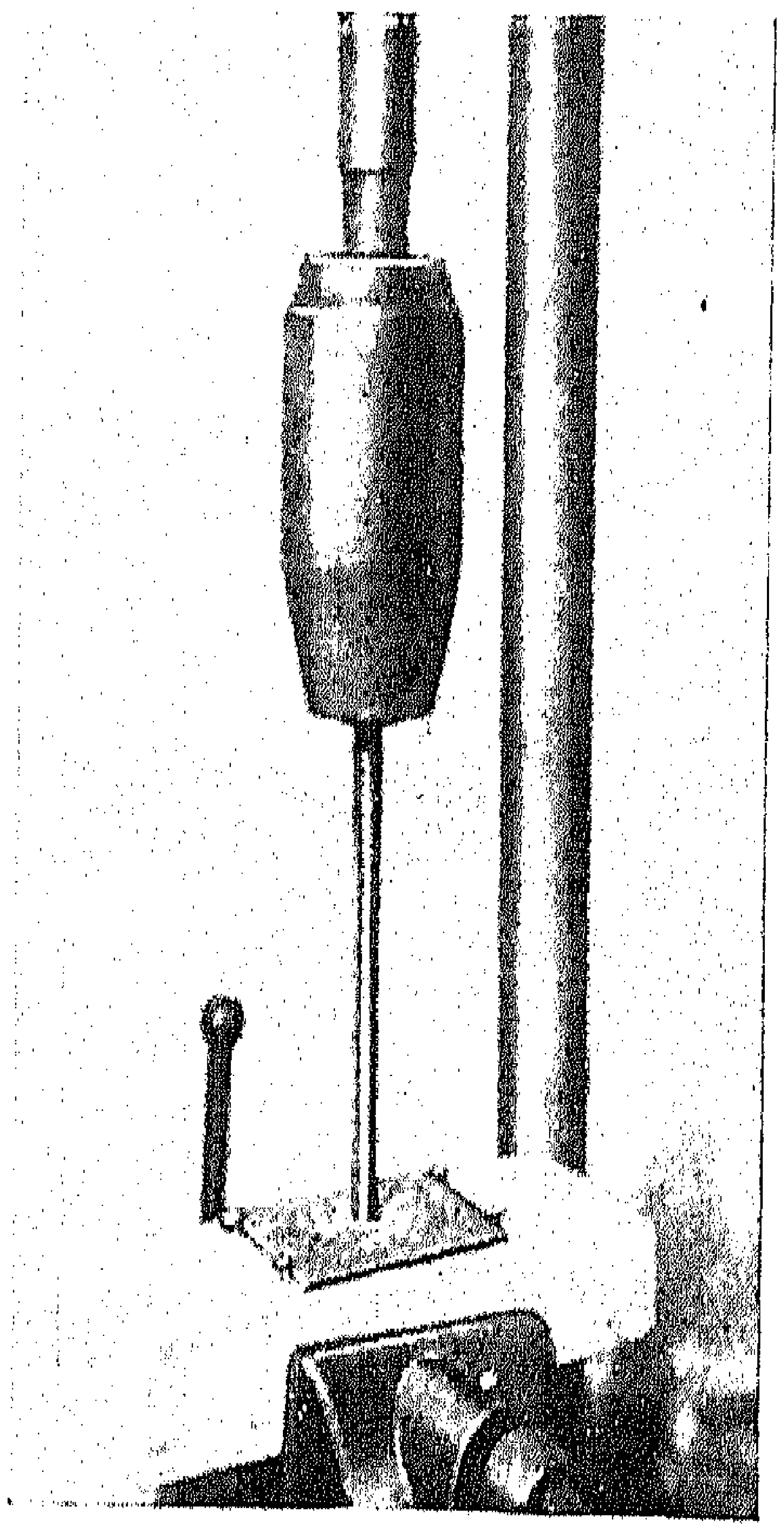


Fig. 6

To Grind a Twist-drill properly is not a difficult job if a proper drill-grinder is available. The tools are somewhat expensive and therefore generally beyond the scope of the amateur. "Touching up," however, can be easily accomplished on an ordinary carpenter's oil-stone.

Twist-drills are unsuitable for making holes in sheet metal, as they have a tendency to catch when breaking through the hole, with the result that a drill is very quickly broken.

For drilling holes in sheet metal the correct type of drill to use is the straight fluted drill, a drawing of which appears at B in Fig. 3. When drilling holes in thin metal it is a good plan to mount the work on a piece of hardwood to prevent the metal from bending. A few tacks driven into the wood (as in Fig. 6) will prevent the work from rotating.

A Pin-drill (illustrated at B in Fig. 7) is useful for producing a flat surface round a hole in a casting or other piece of work where it is necessary to provide a flat bearing surface for a nut, bolt head, or cheese-headed screw. The pin enters the hole, previously drilled, and steadies the drill, while the cutter trues up the surface. When using such a drill a good supply of oil should be applied to the pin.

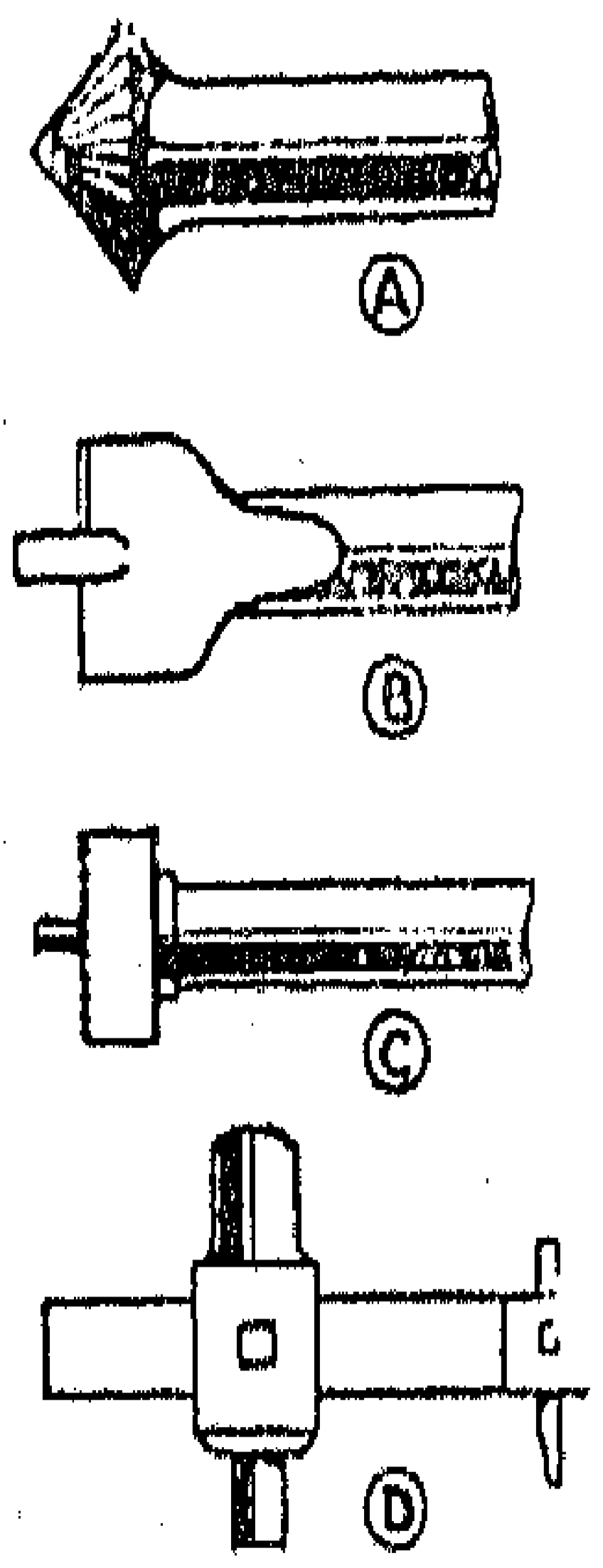


Fig. 7

For countersinking or recessing the mouths of holes to take countersunk screws, a countersink drill (as shown at A in Fig. 7) is the tool to use.

A Bottoming or Arbouring Drill is shown at C. It is used when a flat surface is required at the bottom of a hole previously drilled with a cone-pointed drill. It will be seen from the illustration that the tool is in the form of a circular cutter having a series of cutters set at an angle with the edges, the cutting-edges being backed off in the usual way to provide the necessary clearance.

For cutting large holes in sheet metal, as for instance a water tank, a combination cutter-drill is generally used. Such a drill is illustrated at D in Fig. 7. It consists of a spindle or shank with an adjustable horizontal bar which holds the cutter. At the bottom end of the shank is a guide pin, similar to that in the pin-drill previously described.

To cut a hole, first drill a hole in the work of the same diameter as the pin of the drill. Set the cutter-bar to the desired radius, insert the pin into the pilot hole in the work and rotate the cutter.

Fig. 8 shows a marking-off template which is a handy device to have for rapidly marking the positions of holes when a number of similar parts are to be drilled. Such a template can be easily made with a piece of flat, thin sheet iron provided with a small hole (A) or holes, to coincide with the holes desired in the work, to enable the point of a centre-punch to protrude. The template is held in position on the work and is prevented from slipping by a series of small pins, as indicated in the drawing. The point of a centre-punch is then placed in the hole and a smart tap on the head of a punch with a hammer locates on the work the position required.

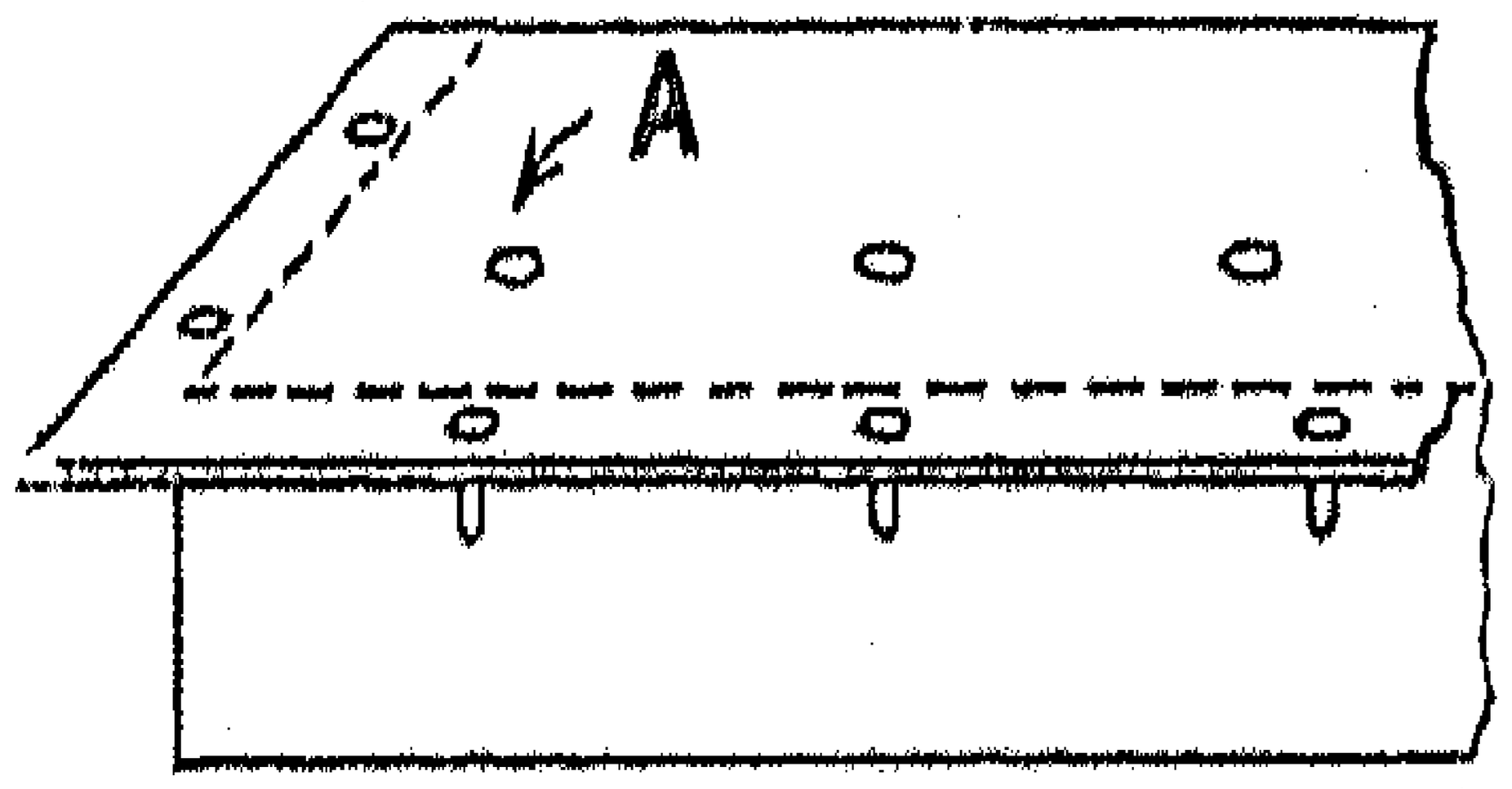


Fig. 8

SCREWS AND SCREW THREADS

Before going into the methods adopted for making screw threads it is necessary to know the technical terms used to define the various parts of an ordinary single-thread screw.

Reference to the diagram at A in Fig. 1, which illustrates the parts of a screw thread, shows that P is the pitch, or the distance measured between the centre of one thread to the centre of the next; H represents the height; T the top of the thread; R the root, or bottom of the thread; and S indicates the slope of angle of the sides.

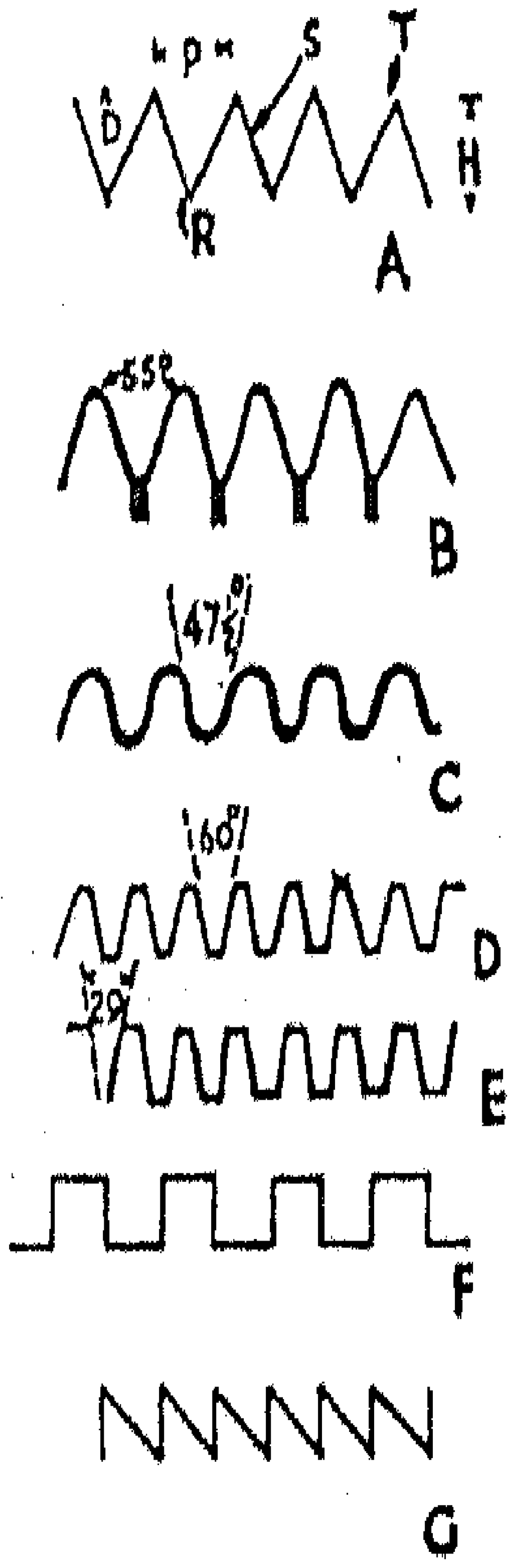


Fig. 1

The form of thread most frequently used in this country for general engineering work is the Whitworth or English Standard thread shown at B in Fig. 1. The angle between the two sides is 55°. The depth of the thread is equal to ·64 of the pitch, and $\frac{1}{6}$ of the height is rounded off at the top and bottom of the thread to prevent damage to the top and also to strengthen the root of the thread.

The British Association thread illustrated at C is a finer-pitched thread than the Whitworth. It is employed for small screws used in electrical apparatus, wireless parts, etc. The angle of the thread is $47\frac{1}{2}$°, rounded at the top and bottom of the thread to a radius of $\frac{2}{11}$ of the pitch.

The main difference between the American Standard or Sellers thread shown at D and the English Standard lies in the shape of the thread. Instead of the top and bottom of the thread being rounded off, they are cut off to form a flat $\frac{1}{8}$ of the pitch in width. The angle formed between the sides is 60°.

Another thread, used largely in machine tools, such as the lead screws in lathes, is shown at E. It is known as the Acme thread. The angle between the sides is 29°.

An ordinary square thread is represented at F. The depth and width of the thread is equal to $\frac{1}{2}$ the pitch. The thrust is at 90° to its axis. This type of thread is weak at the bottom of the thread owing to the absence of metal.

The buttress thread shown at G has one side at an angle of 45°, and the other side vertical. It is stronger than the square thread when the thrust is in one direction only, owing to the extra amount of metal supporting the thread. It is used largely in vice-screws and in cases where pressure is required in one direction only.

There are several methods of making screw threads, which include the use of special threading machines, lathes, and hand-operated tools. The former process does not come within the scope of the amateur, and as screw-cutting in the lathe is dealt with in another article there remains the last-mentioned process of using hand tools.

This is accomplished by the use of stocks and dies for forming external threads and "taps" for cutting threads on internal diameters.

Fig. 2 shows a stock and dies for producing one particular size of thread. The hardened steel die which cuts the thread is made in two halves and is placed in a holder or stock which is provided with an adjusting screw. Pressure is applied to the two holes of the die by means of the screw.

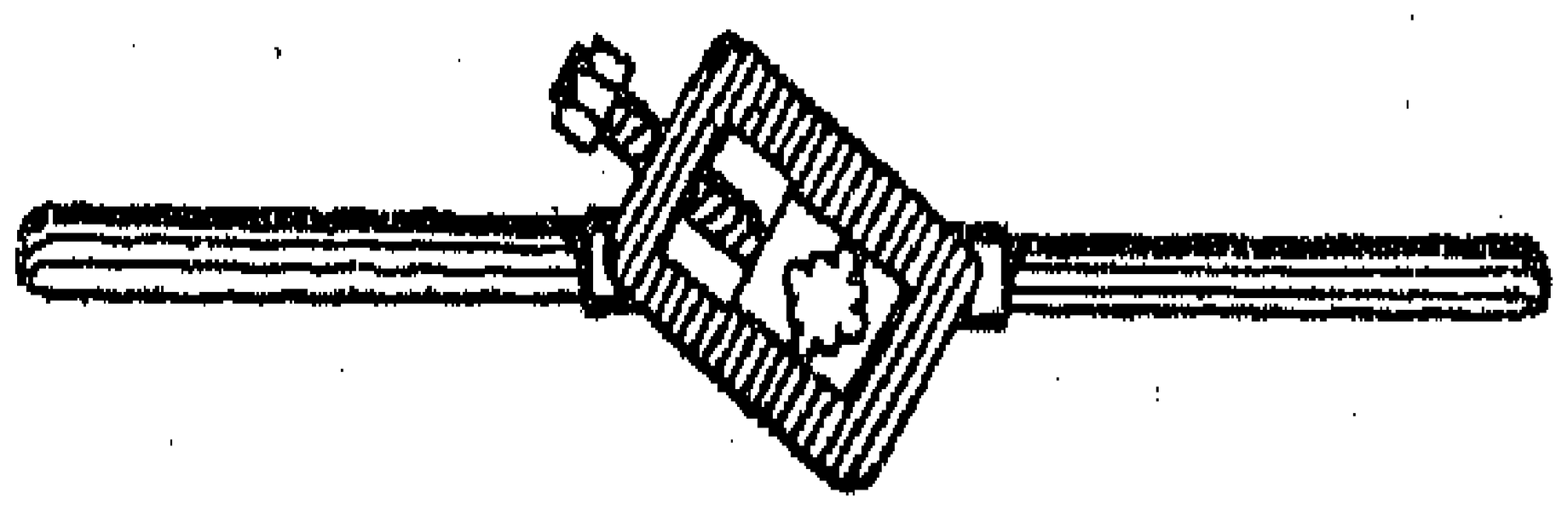


Fig. 2

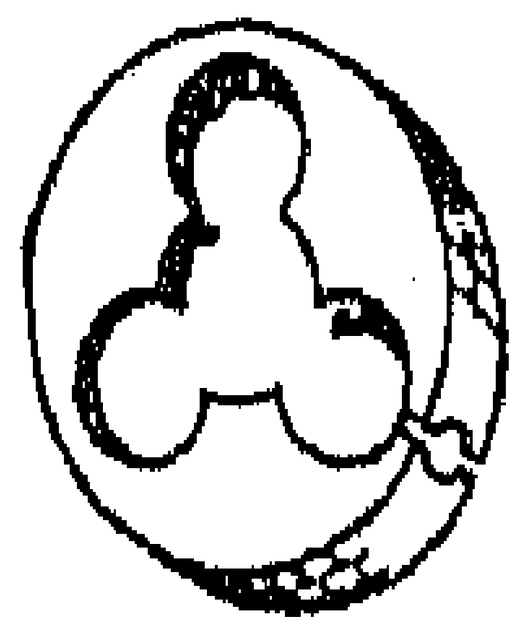


Fig. 3

A set of dies usually consists of a suitable stock with a number of interchangeable dies. In some sets, especially those in the smaller sizes, the stock is designed to take several sets of dies. This method of arranging the latter has the advantage of obviating the necessity of constantly changing the dies when operating with different-sized threads.

Perhaps the most handy and useful pattern of stock and dies for small work, such as model engineering, making wireless parts, and work of a similar nature, is that fitted with spring dies (Fig. 3), which, as their name suggests, are circular in shape and split half-way across to obtain a certain amount of spring. A circular-shaped stock for holding the die is provided with a set-screw which allows the split die to be opened or closed, thus causing the diameter of the thread to be cut to be slightly increased or decreased as the case may be. This feature is a distinct advantage, because it sometimes happens that either a tight or loose screw is wanted and the desired diameter may be easily obtained by adjusting the set-screw. As these dies may be bought separately there is no need to purchase a full set to begin with, but more may be added as required.

The most useful sizes for model engineering and work of a similar nature are $\frac{1}{16}$ in., $\frac{3}{32}$ in., $\frac{1}{8}$ in., $\frac{3}{16}$ in., and $\frac{1}{4}$ in. for cutting Whitworth threads, and Nos. 2, 4, 6, 8, for making B.A. threads.

To Cut an External Thread on a piece of round rod is an easy matter. Fix the work vertically in the vice and file up the end to be threaded to remove the sharp edge and to form a slight taper. Open the die until the work to be screwed can be entered; place the die on the prepared end of the rod and twist the stock round very gently in a clockwise direction, taking care that the die is kept at right angles to the work, or a bad thread will result. When the die has begun to cut, twist the stock backwards and forwards, taking a little more cut at each forward stroke, and continue until the desired length of thread is obtained. Twist the die back to bring it to its original position. Now close the die a trifle and proceed as before and if necessary repeat the operation until the correct-sized thread is obtained.

If the rod being screwed is of iron, mild steel or hard steel, the dies must have a plentiful supply of oil, but if brass is being threaded, no lubricant is needed. Fig. 4 shows an illustration of the process.

To cut an internal thread requires a little more care than that required for forming an external one.

Fig. 5 shows the hand tools necessary for cutting an internal thread. The thread-cutting component is known as a "tap," and the detachable handle a tap-wrench.

Taps are usually made from a rod of cast steel of suitable diameter upon which a thread is cut, after which they are, of course, hardened and tempered. Three or more equal grooves or flutes are provided lengthwise down the tap, which form cutting edges for the remaining portion of the thread, while at the top or shank end of the tool four "flats" are usually provided to enable a suitable wrench to be fitted for twisting purposes.

To produce a full-sized thread two taps are usually employed, called the taper and finishing taps respectively. A third tap, known as a plug tap, is generally used for special purposes.

The threads of the first or taper tap taper gradually from its lower end to within a few threads of the top, the threads on the lower end being ground away to enable the point to enter the hole. In the case of the second or finishing tap, the taper is more gradual and starts from the point to about only one-third up its length, the remainder being left full size.

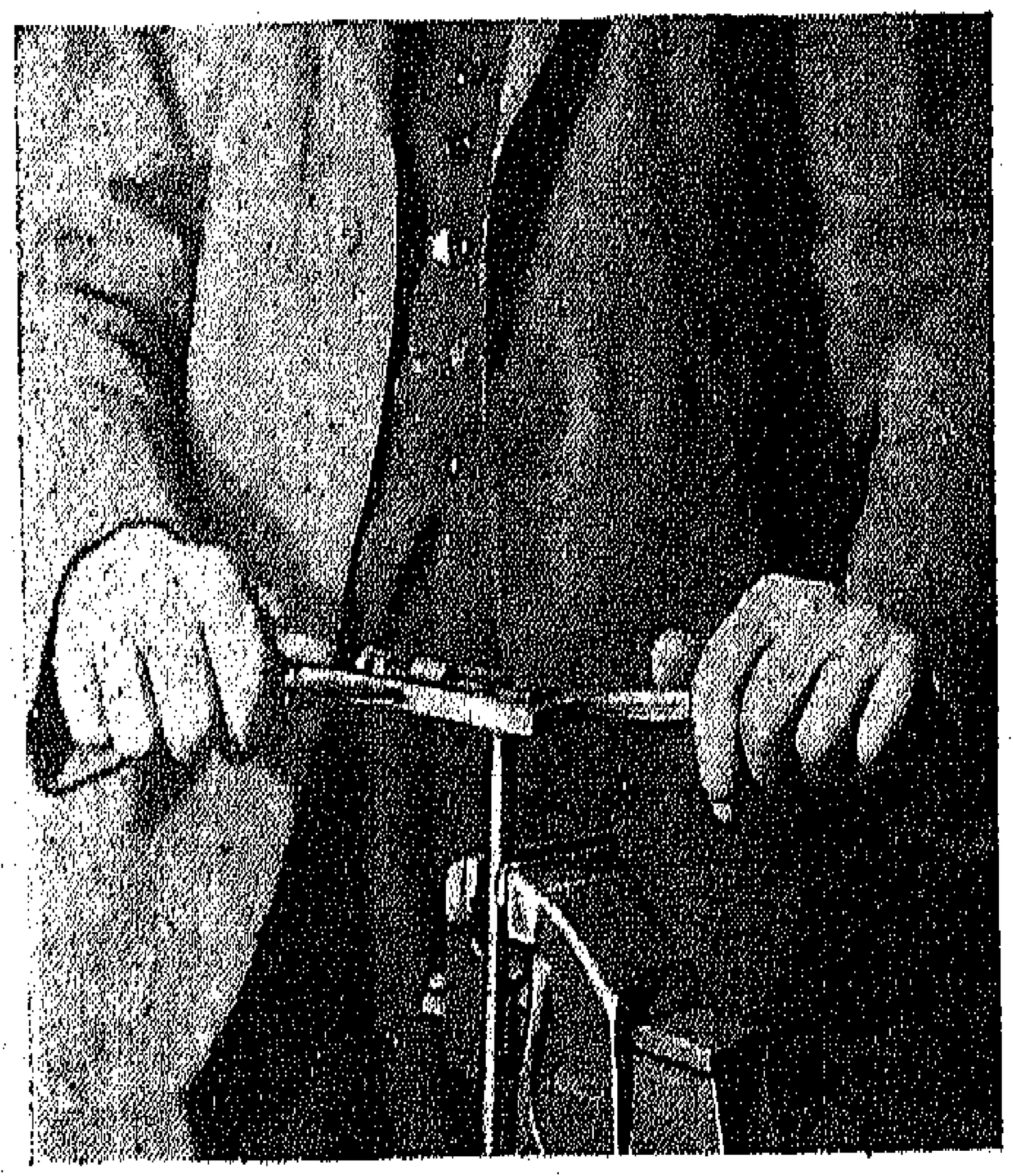


Fig. 4

The plug tap is generally used for tapping holes which do not extend right through the metal, and has a full-sized thread nearly the whole of its length.

A very useful holder for small taps is shown in Fig. 6, and as it is inexpensive it should be included in every metal worker's tool kit. It has a chuck which can be adjusted to take various-sized tools within its capacity.

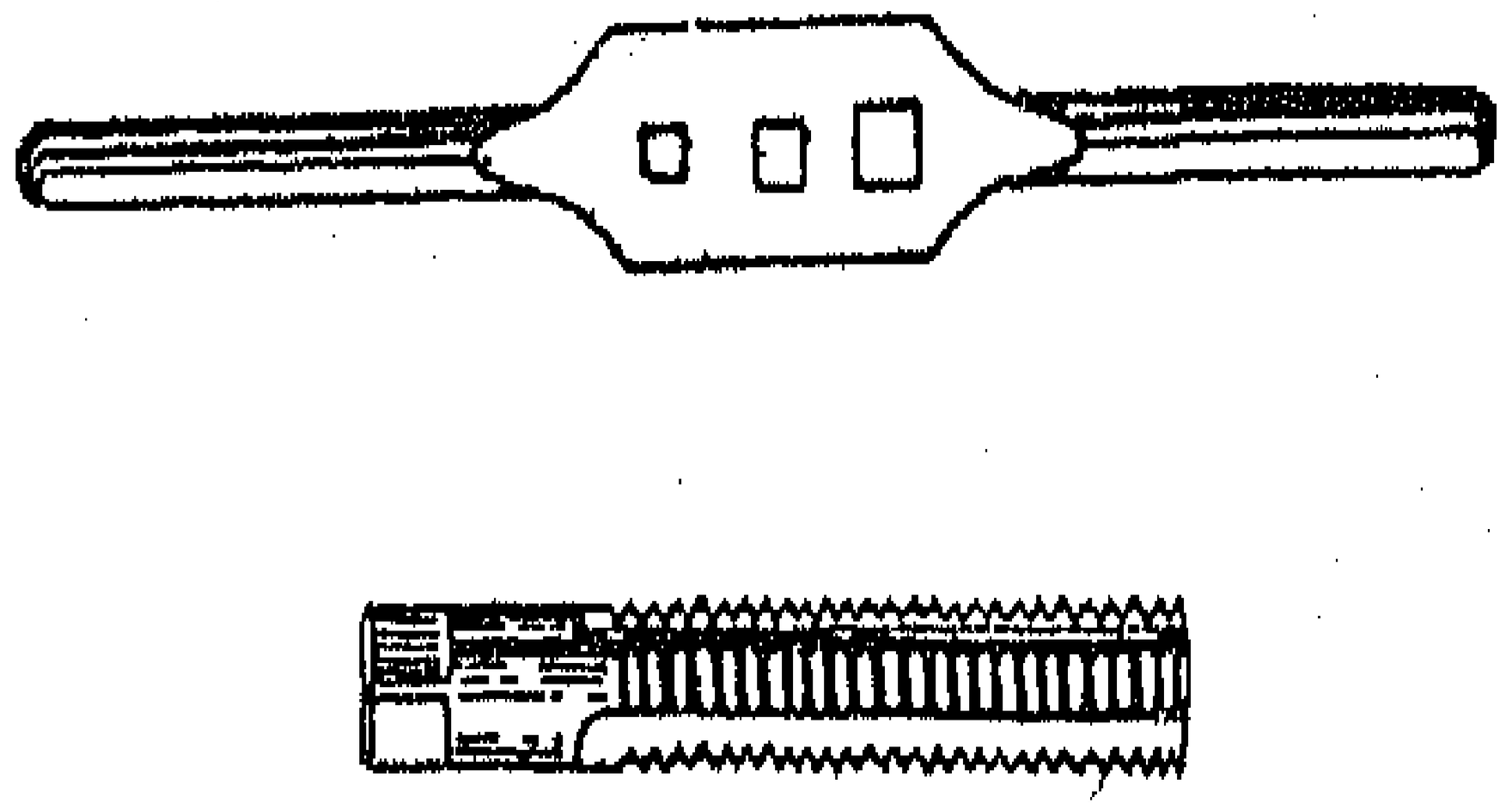


Fig. 5

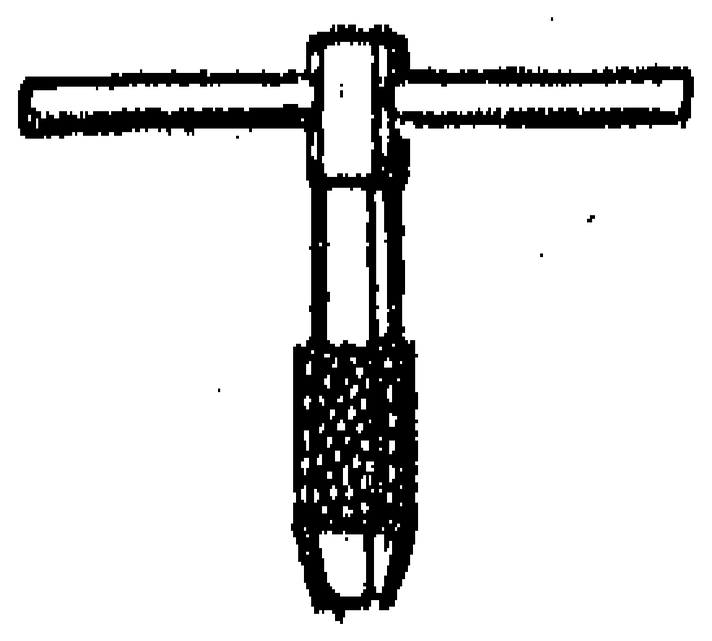


Fig. 6

To Cut an Internal Thread in a piece of metal it is necessary first to drill a hole of the correct size and then cut the thread with the taps. The size of the hole must be equal in diameter to that of the diameter of the bottom of the thread of the screw it is intended to fit. Thus, if it is desired to fit a $\frac{1}{4}$-in. Whitworth screw or bolt, the drill must only be $\frac{3}{16}$ in. diameter. Such a drill is called a "tapping-size" drill.

The following is a table of screw threads giving the corresponding tapping-size drills. It will be found useful for ascertaining the correct drill to use for all usual sizes of Whitworth and British Association threads. The worker who cannot afford a complete stock can therefore buy what he wants without risk of error.

SIZES OF TAPPING DRILLS FOR WHITWORTH THREADS

Diam. of Screw in.	*Diam. of Tapping Drill* in.	*Diam. of Screw* in.	*Diam. of Tapping Drill* in.
3/16	9/64	3/4	5/8
1/4	3/16	13/16	11/16
5/16	1/4	7/8	47/64
3/8	19/64	15/16	51/64
7/16	23/64	1	27/32
1/2	13/32	1 1/8	61/64
9/16	15/32	1 1/4	1 1/16
5/8	33/64	1 3/8	1 11/64
11/16	37/64	1 1/2	1 19/64

SIZES OF TAPPING DRILLS FOR B.A (BRITISH ASSOCIATION) THREADS

Diam. of Screw	*Diam. of Tapping Drill*	*Diam. of Screw*	*Diam. of Tapping Drill*
0	No. 10	5	No. 37
1	No. 17	6	No. 43
2	No. 24	7	No. 46
3	No. 29	8	No. 50
4	No. 32		

Having decided upon the proper-sized drill to use, place the material in a vice and drill the hole in the usual manner. Fix a taper tap in the wrench or holder and screw the tap into the hole. When the tool starts to cut, work the tap gently backwards and forwards, gradually making a little more cut on each forward stroke. The tap must on no account be forced or wrenched sideways or it will break. Continue cutting until the top threads of the tool are level with the top of the hole, not forgetting to apply a liberal supply of oil if working with wrought iron or steel. When tapping cast iron do not lubricate as it causes the chips to adhere and often produces a faulty thread. Remove the tool by twisting it out of the hole and follow on in the same manner with the finishing tap. Fig. 7 shows an internal thread being cut.

One of the most important points to observe when using taps is that equal pressure must be used on both sides of the wrench when being twisted. Failure to take this precaution will undoubtedly lead to a broken tap, which if it breaks in the hole is a very difficult job to extract. Another point to watch is to see that the cutting edges of the tap are in good order, as it is useless to try to form a good thread if any of the cutting teeth are broken. In the event of broken teeth the teeth should be ground down before using. Special care is also necessary when tapping a thread in a blind hole—that is, a hole with a bottom to it. In this case the taper and finishing tap may be driven very gently down to the bottom of the hole and then followed by the plug tap, which will cut a full thread right down to the bottom. When using the plug tap, take very small cuts and see that the chippings are cleared as often as necessary so that the tool can be screwed right to the bottom.

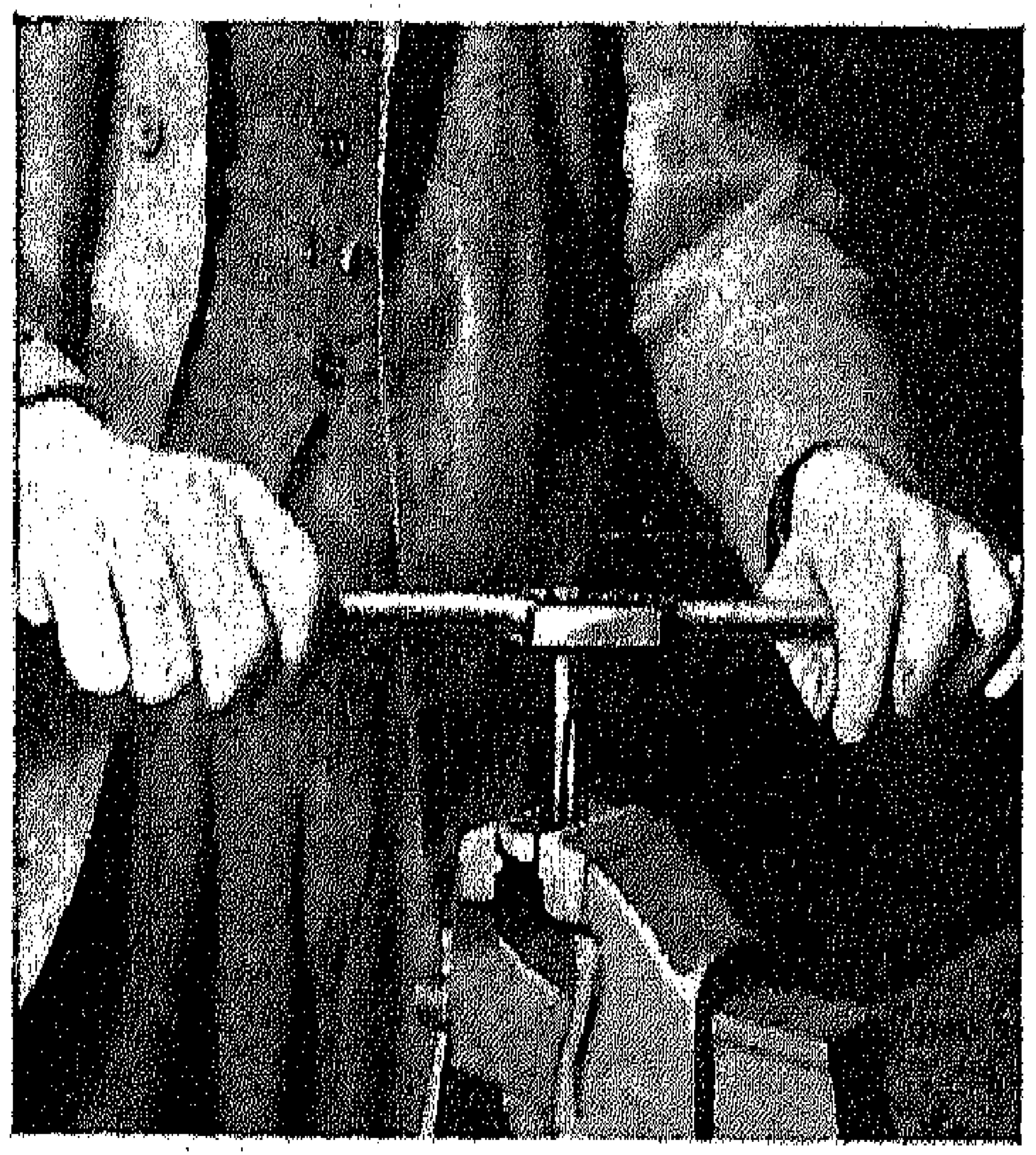


Fig. 7

If you have the misfortune to break a tap and have not a spare one at hand, it is not a very difficult matter to make one.

For a plug tap, cut off a piece of tool steel of the proper diameter and length. File the metal for a distance of about three threads to form a slight taper. If a lathe is available this is an easy matter, for the metal can be fixed between the jaws of a self-centering chuck and filed

as the metal revolves. Now cut a thread with a suitable die opened slightly larger than the finished thread is to be, and then take a second finishing cut, using plenty of oil as a lubricant. If the tap has to have flutes, take a triangular file and rough file where the flutes are to be. Now take a round file and finish off the flutes, remembering that the hollows are deepest at the lower end and gradually get shallower at the shank end of the thread. When the lower tapered threads have been backed off and a square is filed on the shank to fit the wrench, the tap is ready for hardening.

To Harden the Tap, heat it up to a bright cherry red by either holding it in the flame of a blow-lamp or Bunsen burner and quench it in cool water. When doing this, plunge the tap vertically into the water and stir it in circles to ensure even cooling. The tap is now hard and brittle and therefore must be tempered. Polish the tool with emery-paper so that it is perfectly clean and bright. Twist a length of wire round the lower end of the tap to form a holder. Now pass the whole tap horizontally through the flame, allowing the shank end to get the most heat. Watch carefully the change of colours as the heating proceeds and when the end of the tool attains a straw colour, plunge it vertically into cold water.

The method of making taper taps is the same as that just described but the taper tap has the lower end filed or turned taper up to about eight threads and from there up to the shank is parallel.

To make a die, get a piece of tool steel of the same diameter as the outside diameter of the die is to be and file up both faces to the thickness required. Mark out the exact positions where the clearing holes and the centre hole are to be. Drill out the clearing holes first and then plug them by driving in small mild steel plugs. Next, drill the centre hole to the exact size, which must be the root diameter of the thread. Countersink one end of the centre hole to a depth of about three threads and do likewise at the other end to the depth of one thread only. Grip the die firmly in the vice, keeping the tapered end uppermost, and tap the hole, using a taper tap for the purpose. Do not forget to use plenty of oil in so doing. Repeat the process with the finishing tap. The next operation consists in cutting the adjusting slot. Drill a small hole near the edge of the die in such a position as to leave a thin wall of metal between the edge of the hole and the edge of the die. This will leave sufficient metal to prevent the die from warping when undergoing the heat treatment; this is removed by a file when the die has been tempered. Cut the slot by using a small metal-piercing saw and drill two small shallow countersunk recesses to receive the fixing set-screw and the adjusting screw respectively. Drive out the metal plugs from the clearing holes and back off the rear of the cutting teeth with a small flat file. The die must now be hardened and tempered. Proceed in the same manner as that described for the tap, not forgetting the wire for holding purposes. Heat up the die to a cherry-red colour and then quench. Remove the metal in the slot and polish the die with emery cloth, then draw the temper, which should be a deep straw colour.

RIVETS, BOLTS AND NUTS

WE come now to the consideration of how best to fix two pieces of metal together, for, unlike wood, they cannot be glued or nailed. Often, too, the pieces must still be capable of movement.

The holding together of two pieces of metal in such a manner that they can be adjusted relatively to each other, or separated when required, is accomplished by bolts and nuts and screws. When two pieces require to be permanently attached, or where there is no necessity for separation, or where cheapness, neatness and great strength are required, rivets are used.

Rivets, bolts, nuts and screws are of a very wide variety. Something about their various adaptabilities and how to use them will be useful for reference by the amateur metal worker.

As mentioned elsewhere in this volume, there are several standard screw threads used in this country which have been developed as suitable for various classes of engineering and mechanical work.

The best known is the "Whitworth" standard, which is used for screws and bolts and nuts from $\frac{3}{16}$ in. to 6 in. in diameter. It is in use for practically all general engineering and mechanical purposes. It has a comparatively coarse thread, so the angle of the thread to the axis is rather wider than any of the other threads. But it is very strong and only where great vibration is present need a finer thread be used. The "British Standard Fine" screw thread has a finer thread—more threads to the inch for a given diameter—than the Whitworth. Thus a Whitworth $\frac{1}{4}$-in. screw has 20 threads to the inch. A British Standard Fine $\frac{1}{4}$-in. screw has 26 threads to the inch. This thread is used very largely for motor-vehicle purposes, motor cycles, etc., while for bicycles the thread standard developed by the Birmingham Small Arms Co., and adopted by the Cycle Engineers' Institute (before it became the Institute of Automobile Engineers), has been largely adopted. This is a fine thread and the nuts and heads are much smaller relatively to the bolt diameter than in the case of the Whitworth standard.

For small work, instruments, small accessories, such as carburettors and electrical apparatus, necessitating the use of small screws, the standard thread which the amateur will most commonly need is the "B.A." or British Association Standard thread. The range of threads goes by numbers, not fractions of an inch, and is based on the metric system. The largest size in the standard is denominated "0" and is 6 mm. in diameter, with a pitch of 1 mm The sizes downwards go by numbers upwards up to No. 25, which is ·25 mm., or a quarter of a millimetre in diameter.

Tables of these threads are to be found in all mechanics' text and pocket books, and space need not be devoted to them here. These tables give the sizes of the nuts and of the heads as to their thickness and their measurement across the flats of the hexagon in the case of hexagon-headed bolts and screws. They also give, as well as the diameter over the thread (which would be the diameter of a clearance hole), the diameter at the core, i.e. measured at the bottom of the threads.

This core diameter is important, as it provides data as to the size of hole to be drilled for tapping to the correct size for the screw selected. But here some advice is needed. If a hole of the core diameter is drilled in wrought iron and an attempt is made to tap it with a standard tap, to take a standard screw, the tap will most likely jam and break. In any case the hole, when tapped, would be very tight on the screw—probably too tight to allow the screw to be screwed in, or so tight as to hold and seize the screw, which would be broken off in the hole in an attempt either to screw it in or out. On the other hand such metals as cast brass will not "flow" in this way, and the tapping size drill will make a hole which will allow the tap to cut a screw-thread to suit the bolt or screw. Cast brass will not flow. Copper will flow Cast iron will not flow. Drawn brass—as rods (squares, rounds, etc.)—sometimes flows a little. Therefore, for cast iron and cast brass it is sufficient to drill a hole of the specified tapping size, but for wrought iron, copper, brass, etc., the hole should be slightly larger than the tapping size specified. The metal will flow towards the centre of the hole and give a good thread.

In the case of aluminium great care should be exercised, because it is of a very tenacious nature and "holds on" to the metal of the tap. Often the tap will "seize up" in the hole, at other times it will not feed in freely, and will rip all the thread out after the tap has been turned for a few rotations. More clearance should be given as regards the tapping size of the hole in aluminium than in the case of any other metal. If you are drilling and tapping large-sized holes—say, anything above $\frac{1}{4}$ in.—in aluminium, it is a good plan to grind away every third tooth on the tap on each of the three rows of teeth—the blanks to alternate. Such a tap will cut a clean unbroken thread in aluminium, where a full-toothed tap will simply jam up or tear out all the thread from the hole.

Lubrication is essential in the case of tapping some metals and should be avoided in others. All the ferrous metals—steel and iron—should be lubricated with oil when being threaded. Copper and brass and copper alloys should be tapped without lubricant and aluminium should be lubricated with turpentine—not lubricating oil. The use of turpentine on aluminium is very essential. In turning aluminium in the lathe, for instance, it will often drag and tear on the edge of the tool, thus spoiling the work. Sometimes the tool will get hold of it and embed itself so far as to pull the work from between the centres or out of the chuck. Turpentine used as a lubricant when turning, sawing, cutting or tapping aluminium will result in the avoidance of these troubles.

Nuts should be an easy fit on bolts. They should run down the whole length of the threaded portion by being rotated by hand, but they should not be "rocking" loose at any part. In using nuts, always lubricate the bolt with oil before applying the nut. This will result in allowing of a much farther turn at the final tightening up; furthermore, the nut will be less liable to slack off. This may seem a contradiction, but experience proves its truth. In dealing with any machinery, always lubricate the threads of studs, bolts, etc., before applying nuts. Even in the case of small instrument screws this holds good and will lessen the risk of breakages of screws in holes when tightening up. Dip them in vaseline.

Many machines have studs screwed into one part, with nuts to hold another part to the part with the studs. Trouble sometimes arises from the studs unscrewing with the nuts. This fault can be avoided by making the hole for the stud deeper than necessary, and tapping it with a taper tap so that the stud binds on the threads when it is screwed down. This happens, of course, just before the end of the thread and the plain part reaches the face of the metal. On occasions difficulty is experienced in withdrawing a stud. The use of hand-grips is to be avoided, since the jaws damage the surface of the plain part of the stud causing difficulty in getting the adjoining piece over the studs again.

To Withdraw an Obstinate Stud, use two nuts and two spanners. Screw down the first nut nearly as far as it will go, and then screw down the second nut on top of it. Hold the bottom nut with one spanner and screw the second nut down hard upon it with the second spanner. Then screw the stud out by using the first spanner on the under nut. In very obstinate cases soak the metal round the stud with paraffin oil over-night. The stud can generally be withdrawn in the morning.

Where a stud or screw is broken in a hole, drill it down the centre with a drill of a diameter less than the tapping size of the stud. Take a hardened, square, taper reamer and tap it gently into the hole and turn. This procedure generally has the desired effect. In bad cases drill the full tapping size of the hole. This will leave only the threads of the screw in the threads of the hole. Be careful to drill straight and central. Then use a taper tap, which will generally strip the metal out without injuring the thread in the hole, especially if the tool is withdrawn and cleared a few times, and the loose metal (which it turns out of the thread) picked away from the thread with a pricker or steel scriber. Small screws which have broken in the holes may often be removed by using a flat drill, ground left-handed and turned left-handed. After a few turns of the drill the screw will possibly begin to turn out of the hole as drilling is continued.

When fitting bolts to holes always slightly countersink the edge of the hole. If this is overlooked, the head, instead of lying flat on the metal, will only really be holding by the slight rounding in the corner where the shank of the bolt meets the head. It may seem to be tight down, but the under surface of the head is not actually resting on the metal, and such a bolt, under working strain, will certainly loosen and slack off, due to vibration.

Use a spring washer under all nuts and bolts of machines subject to vibration and on motor-car and motor-cycle work; and on all engine work use castle nuts and split-pins passing through holes in the bolt ends. Do not use a split-pin smaller than the hole it occupies. A sloppy-fitting split-pin is dangerous, because it gives a nut a chance to loosen and, in so doing, it may shear the pin. Let the split-pin fill the hole in the bolt.

In the case of rivets always have the holes in the two parts to be joined together dead in line with each other. On particular work especially, drill two pairs of holes first to locate the parts and then bolt them together with bolts which fit the holes tightly. Then drill the rest of the holes through both pieces. Always, on important jobs, slightly countersink the holes in the surfaces which meet. This prevents shearing and makes a stronger joint.

When Drilling through Two Plates together for riveting, the drill invariably pushes tiny twists of metal between the plates, which, when they are riveted up, prevent close contact and therefore weakens the job. After drilling, unfasten the two parts and slightly countersink the holes on their adjacent sides. This operation, trifling as it may seem, often makes the difference between a good fit and a bad one, especially in small work. The rivet should fit the hole. Badly-fitting rivets may seem tight through the riveting, but the parts will move eventually, because the holes are

bigger than the rivets, and the friction of the heads is the only thing which is preventing the parts moving endways. When there is doubt about the holes being dead in line, or the job is a very particular one, reamer the holes in situ, and see that the rivets are a tight fit before riveting.

When riveting see that the head is tight up to the surface and the hole slightly countersunk. Let the first blow be a smart one, dead in line with the axis of the rivet—and let nothing but the head of the rivet rest on the anvil or block or vice or whatever you are using as a "hold up" for the rivet head.

Then, begin with the round peen of the hammer, to drive the edges down, going round the rivet with about eight or ten blows to the circle. Hit the edge of the rivet at 45° to the flat of the metal being joined. The idea is to drive the metal down at the top so that it spreads at the bottom. Practice will enable one to give a good finish with the hammer; but a rivet snap (a tool with a half-sphere indented in its hardened end) may be used to give a uniform appearance—as in the case of closing rivets on the seam of a model steam boiler. When flush riveting, i.e. when the plain end of the rivet is to be spread out in a countersunk hole, use the round peen of the hammer and strike the rivet vertically, dead in the centre so as to swell it sideways. Then, when the rivet has spread to the diameter of the outer edge of the countersunk hole, drive it down with the flat face of the hammer. Let the rivet project far enough to ensure that it will spread the full width of the countersink, and if it overlaps when riveted, file it down.

Avoid having the rivet too long. Under such conditions it may bend, rendering a good sound joint impossible to make. A bent rivet should always be drilled out and a new rivet used.

Few amateurs will require to do any hot riveting, but some points about it may be mentioned. The rivets must be a trifle smaller than the hole so that, when red hot and expanded, they can be pushed just easily through the hole. The rivet should be a red heat, but not a glowing one, and it should be "closed" quickly. It must have its head held up tight to the surface of the metal by means of a heavy piece, such as a large hammer, otherwise it may expand in the hole when hit, and the rivet head may not come down on the outside surface of the piece. Consequently it will then be holding only by friction, and will be loose when cold. The procedure is the same as in cold riveting, except that the hammer blows, when closing the rivet, should not be so hard.

Splitting of cold rivets is due to tapping at them instead of hitting them hard. The outer surface of the metal is hardened and cracks by tapping, while the mass is unaffected. Always use good rivets and throw out rivets which have a "fin" below the head or along the shank. They cannot make a sound job.

SMITHS' WORK

SMALL smithing jobs can be done on a hearth which is made to stand on a bench and supplied with air blown from a portable foot-bellows. Such a device will generally be big enough for any work the amateur may have in contemplation. The bellows shown in Fig. 1 will supply a continuous blast of air of sufficient volume to reduce steel or iron of $\frac{1}{2}$-in. section to a welding forging (fusing) heat. The size is 14 in. measured across the base which should, preferably, be screwed to the floor. It should be coupled to a portable hearth (shown in Fig. 2). This can be made of $\frac{1}{16}$-in. black sheet iron cut to the shape and dimensions shown at Fig. 3. The front, back and sides are bent up at the dotted lines, and the edges neatly bent down to give strength and a finish. The V gusset pieces, A, act as overlapping plates riveted through the sides. The blast nozzle, known as the "tuyère," should be of cast iron and of large size. It is cast from a wooden pattern (Fig. 4) and then drilled through with a $\frac{1}{2}$-in. or $\frac{3}{4}$-in. hole and three holes are drilled through the flange to bolt it to the back plate of the forge. Four legs of 1-in. by $\frac{1}{4}$-in. iron are riveted as shown (Fig. 2) to the sides of the hearth, and may be drilled for bolting to the bench or other suitable support.

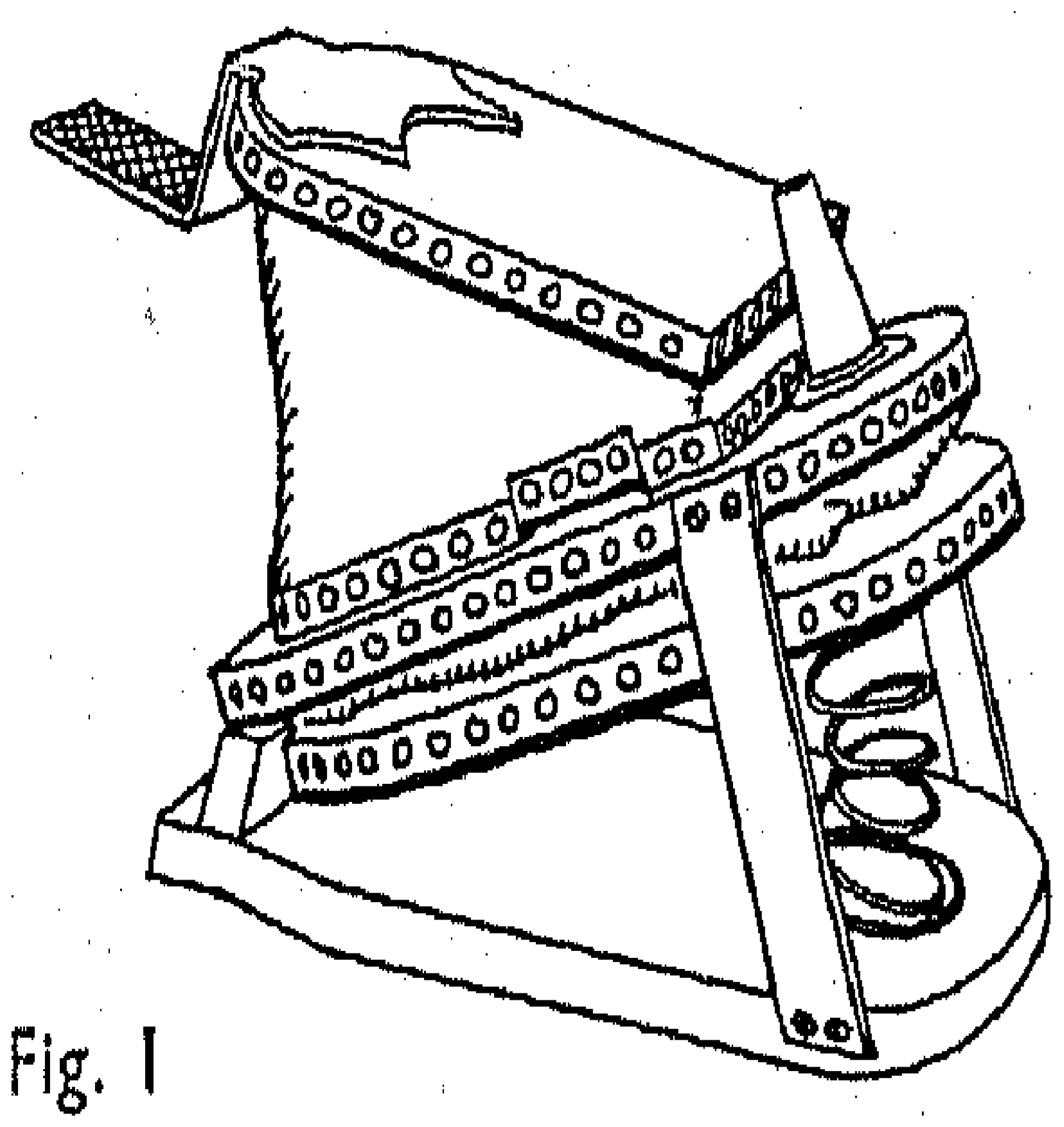


Fig. 1

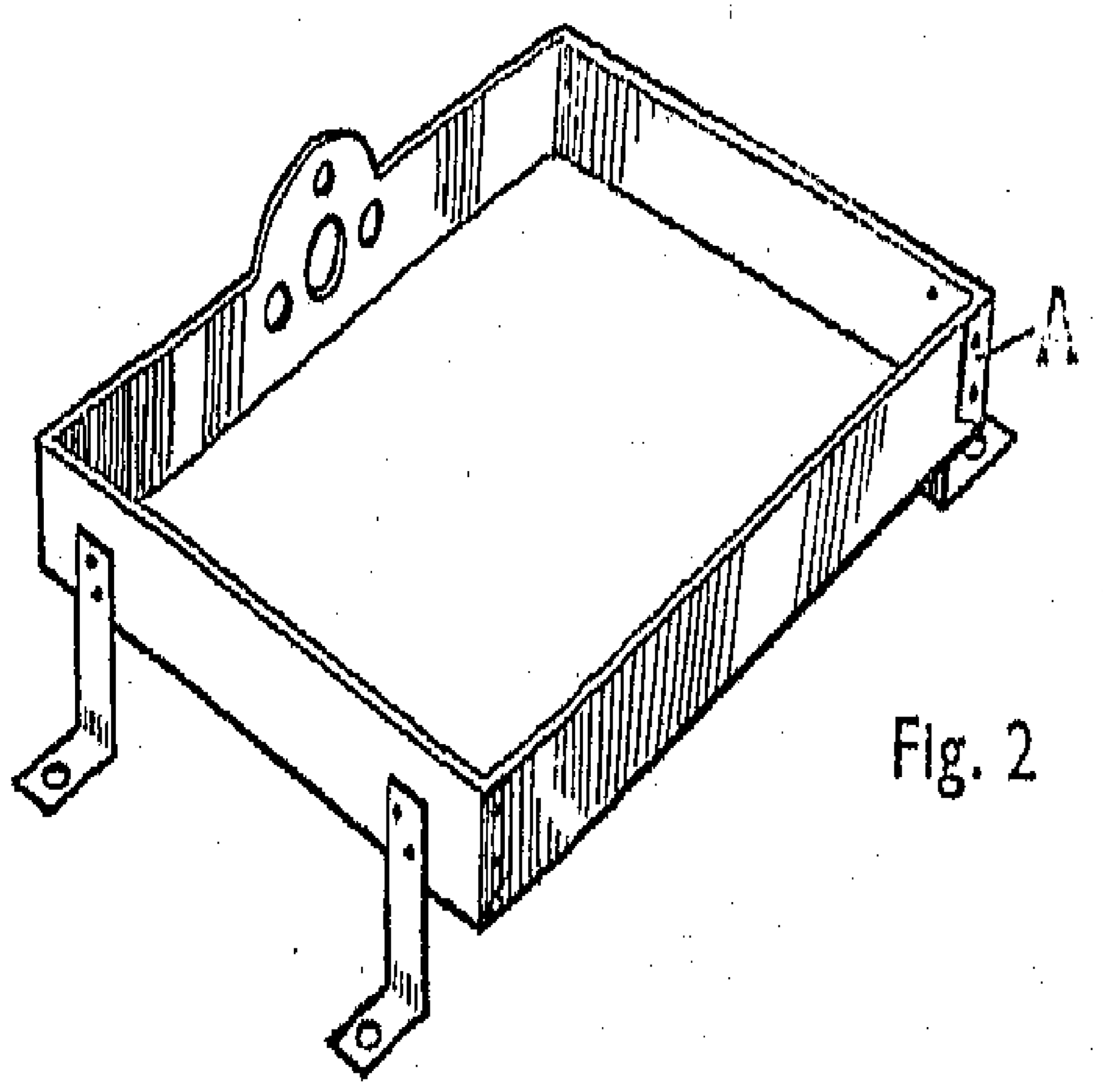


Fig. 2

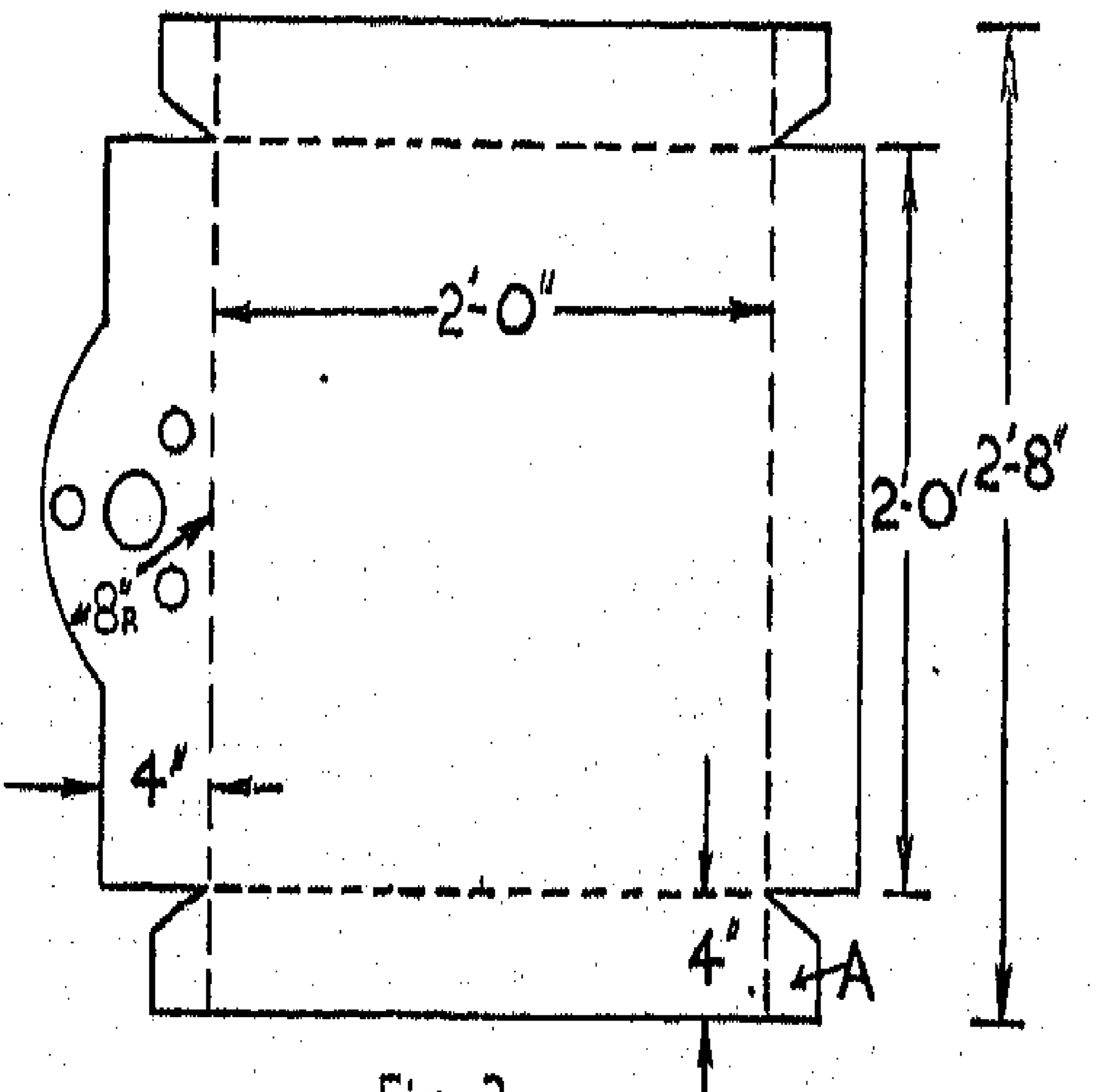


Fig. 3

A length of rubber and canvas motor-car water-circulation hose will couple the bellows to the forge. The hose can be reinforced by winding 18-gauge hard-drawn steel wire round a thin broom handle in a spiral of about 6 turns to the inch, securing the ends, inserting the broom handle and the wire into the hose, releasing the wire and withdrawing the broom handle. The ends of the hose should be copper-wired to the bellows and the hearth tuyère.

A 56-lb. wrought iron, steel-faced anvil should be procured. Often one can be picked up in a reasonably good condition at a second-hand tool stores. If an old motor-grease drum is cut in half and filled with sand it will form an ideal support for the anvil and will deaden noise and shock. This item is shown in Fig. 5.

The Fire is the most important point about smith's work, for the success of the job depends upon properly heated metal. Small coal, known as "smith's breeze," should be used. A hardened mass of caked coal is arranged around and at the back of the tuyère, and may be made by slacking the coal with water sprinkled on. An iron rod is pushed through the tuyère iron while this is being done, and when withdrawn leaves a channel for the air. The fire is prepared by first placing small pieces of wood (or shavings) soaked in paraffin into the cavity formed by the packed breeze, lighting this, and then blowing very gently. As the coal burns, the fire should be banked up with moist coal, and the draught continued. The work is inserted from the side and at a point about 5 in. from the blast orifice. A rake is used to draw the coal into position; the idea is to keep the work unexposed to the atmosphere. Coal is drawn from the front to make up for that burnt—and not from the back, which should be kept packed tight.

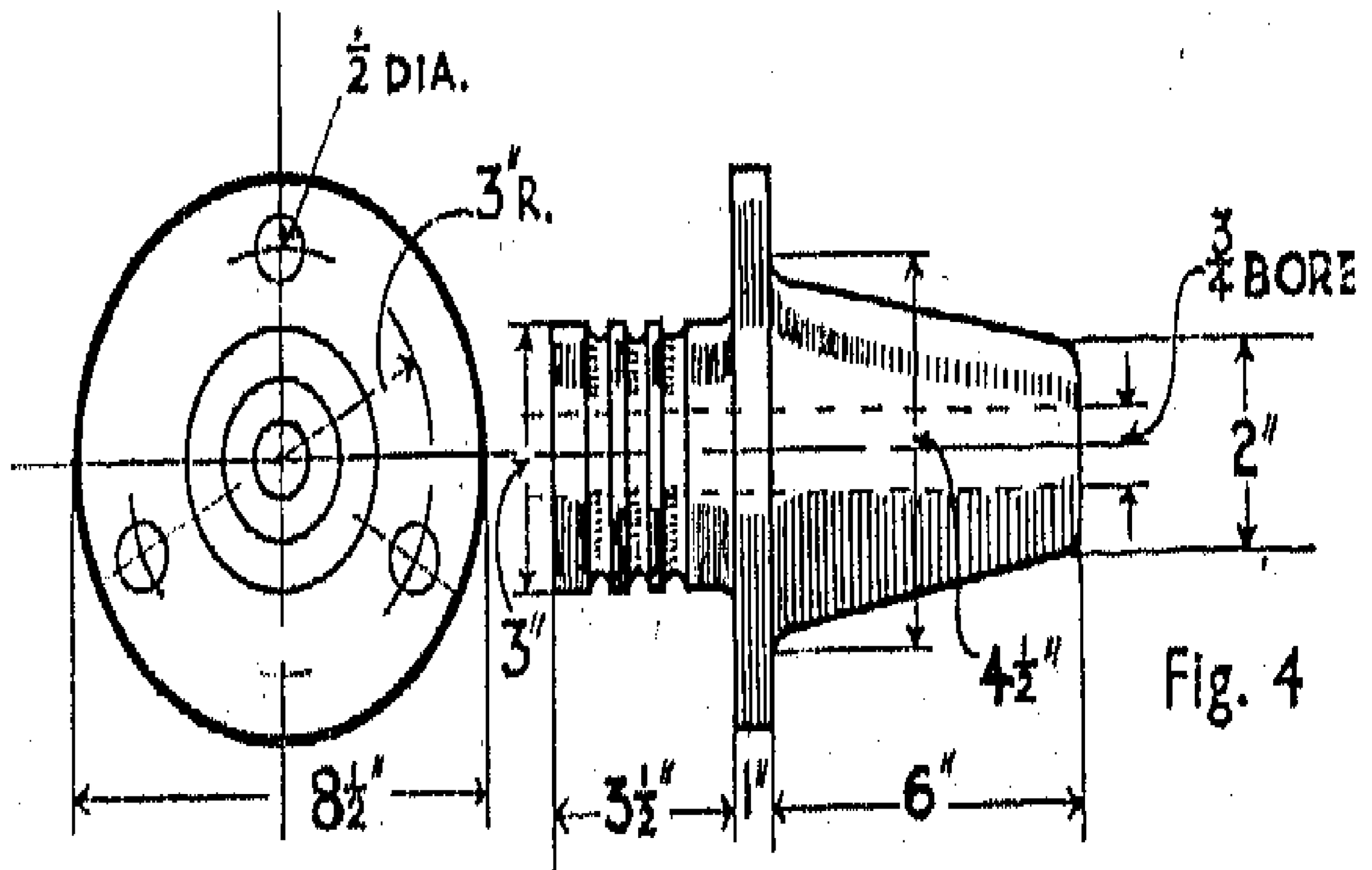


Fig. 4

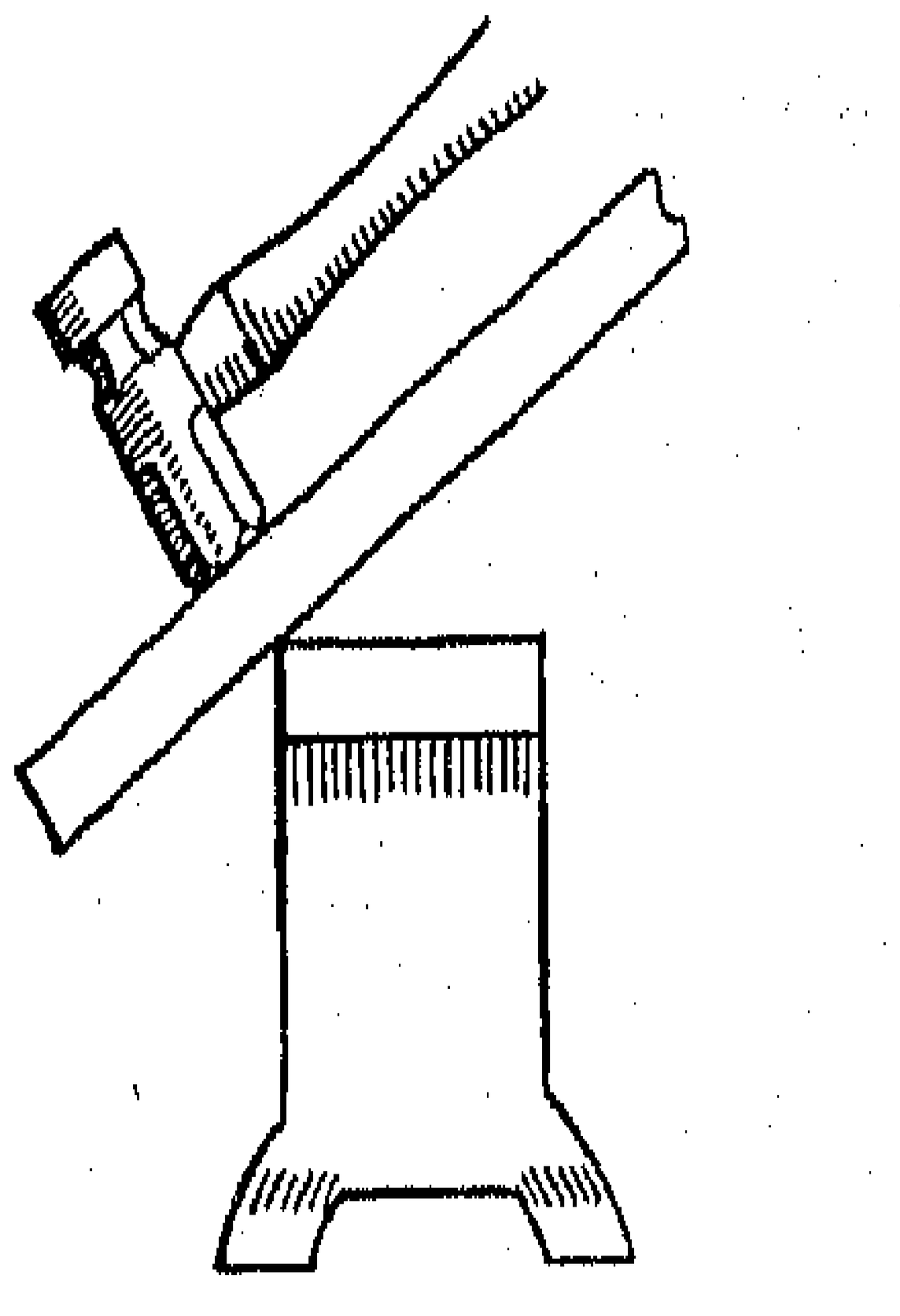


Fig. 6

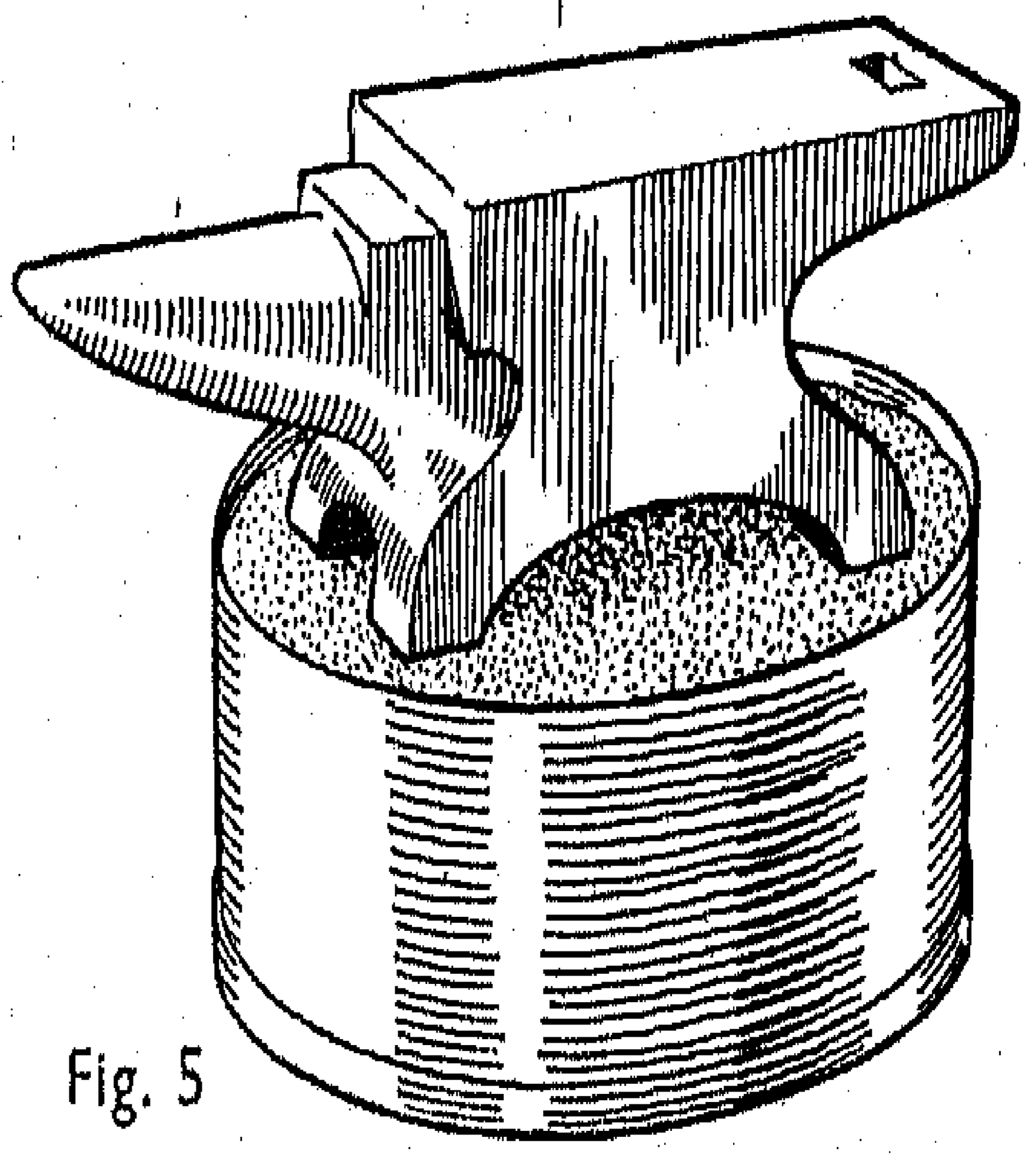


Fig. 5

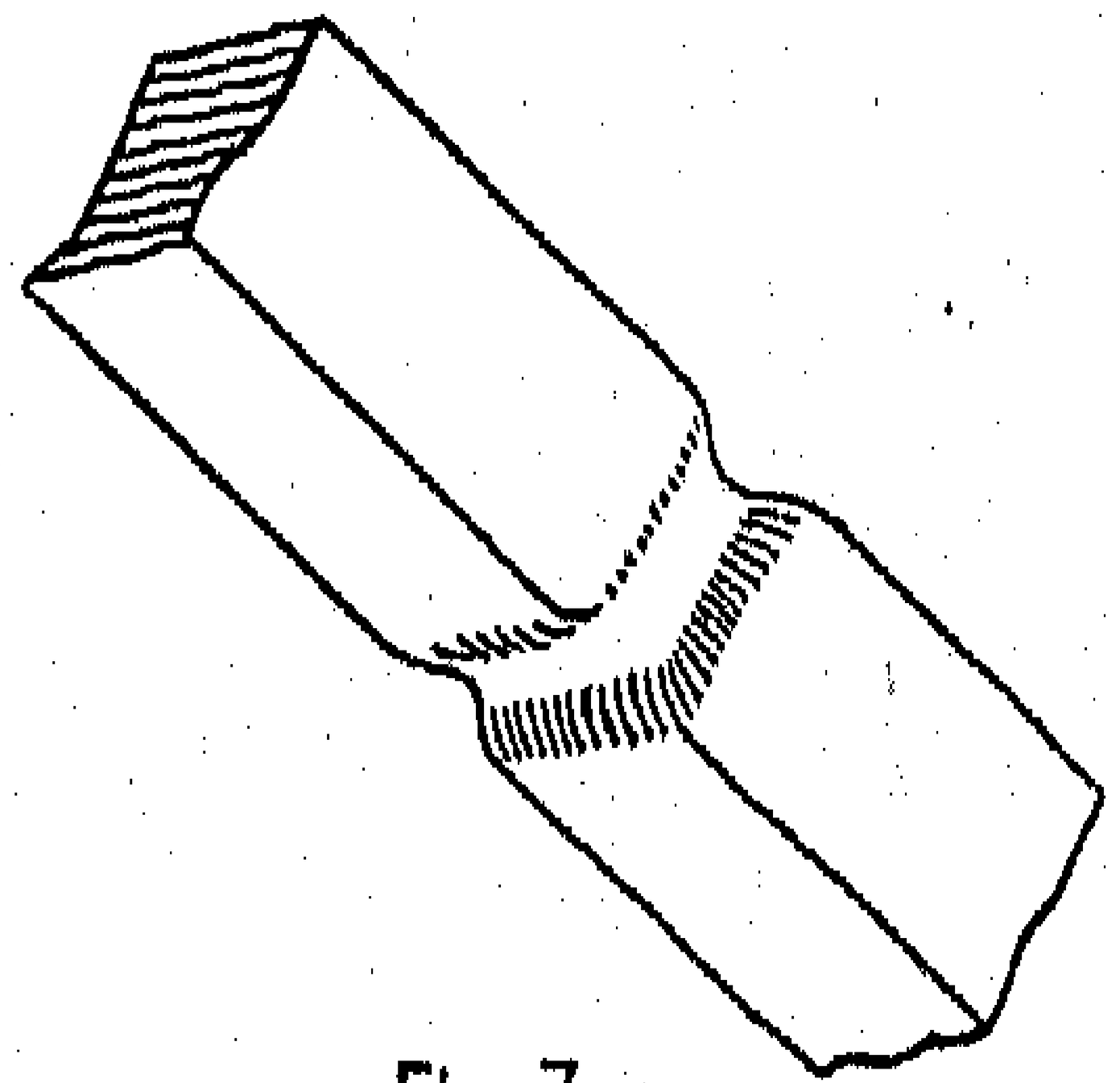


Fig. 7

Forging consists in drawing down, upsetting and welding; but the various operations merge into each other.

In drawing down (from a large to a small cross-sectional area) the red-hot bar of iron is laid diagonally across the edge of the anvil and a blow given it with the flat peen of the hammer as in Fig. 6. This nicks the material without cutting it, and the depressions so made around it should be of a depth to equal the outside measurement of the part to be reduced, as illustrated in Fig. 7. The flat of the hammer is then used on the still red-hot end of the bar and the metal reduced in thickness, beginning at the end and working to the depressed position, turning the piece over between every two or three blows, and gradually working back. If a round bar is being worked upon, it should be continually turned by hand (or by the tongs if it is of small length). In the case of square bars, hammer opposite faces alternately.

Reducing a round bar, as for a bearing, is done in a similar way and finished with a swage. For single-handed working a spring swage (as shown in Fig. 8) is most handy. It can deal with three or four sizes. Bottom swages (Fig. 9) fitting into a square hole in the anvil can be used with a flat-peened hammer for much reducing and rounding work.

A top swage can be used for finishing if an assistant is available.

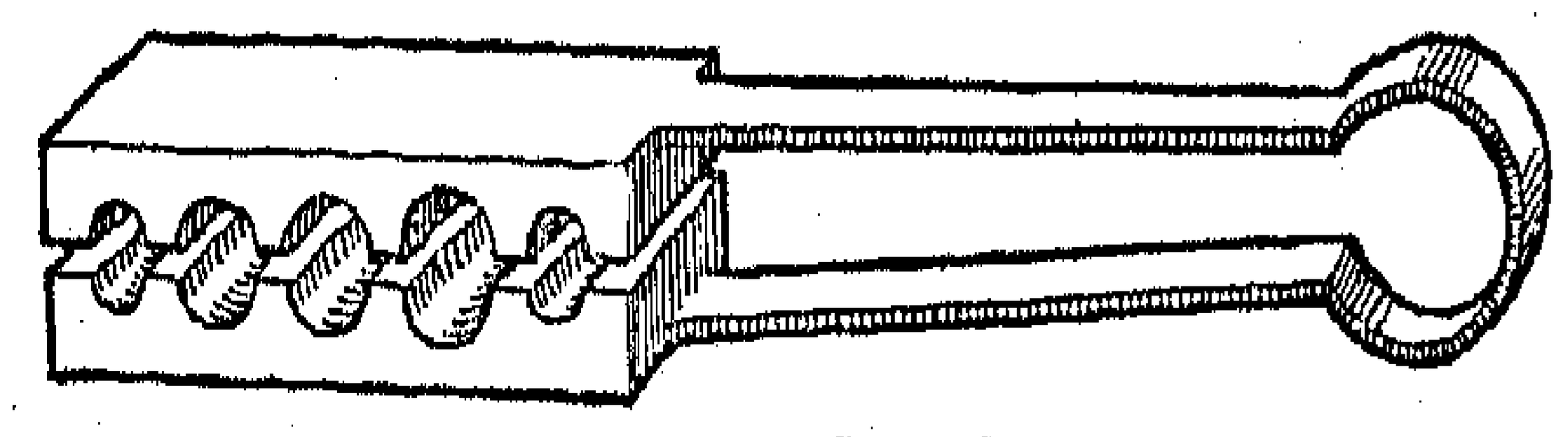


Fig. 8

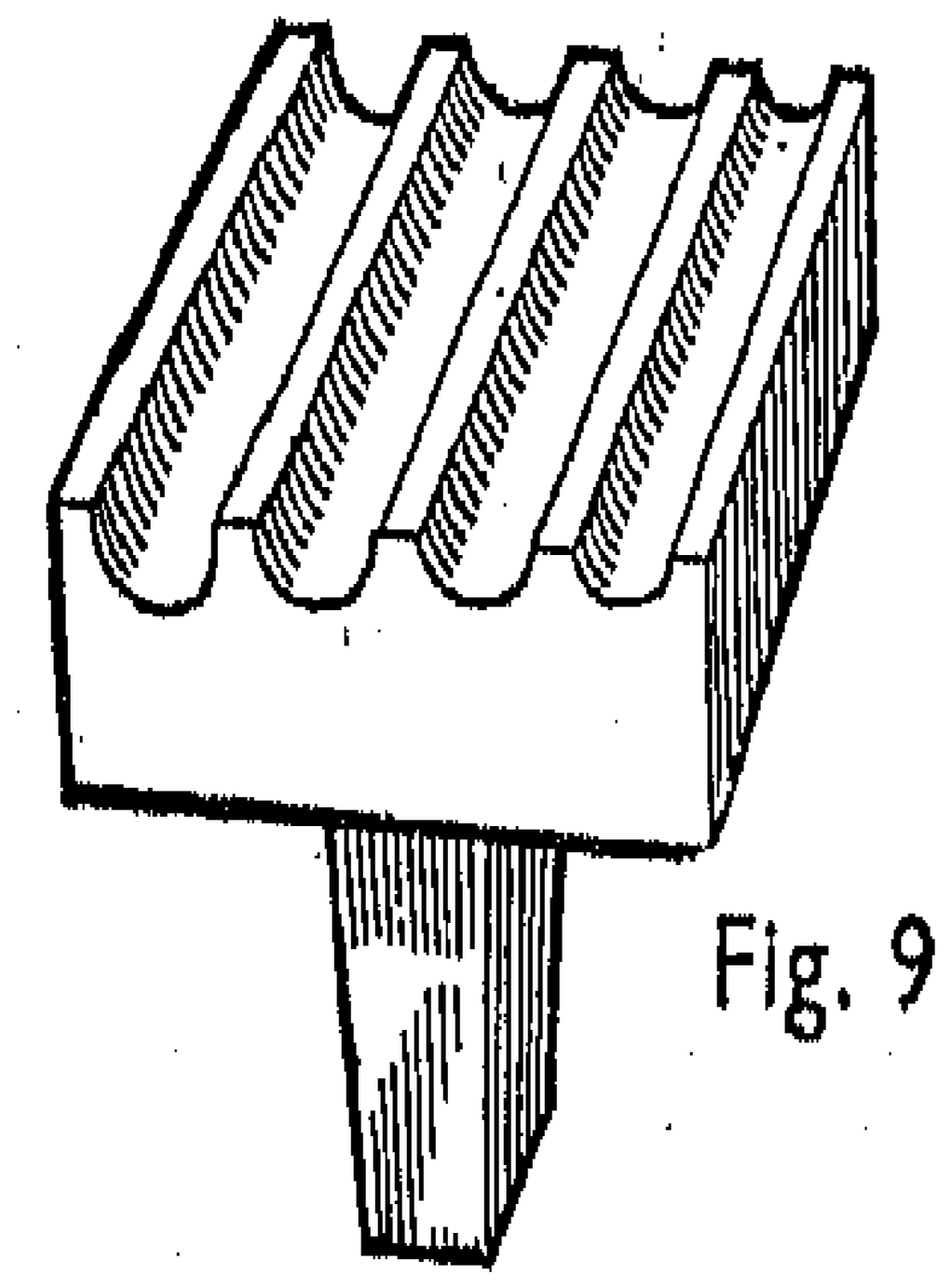


Fig. 9

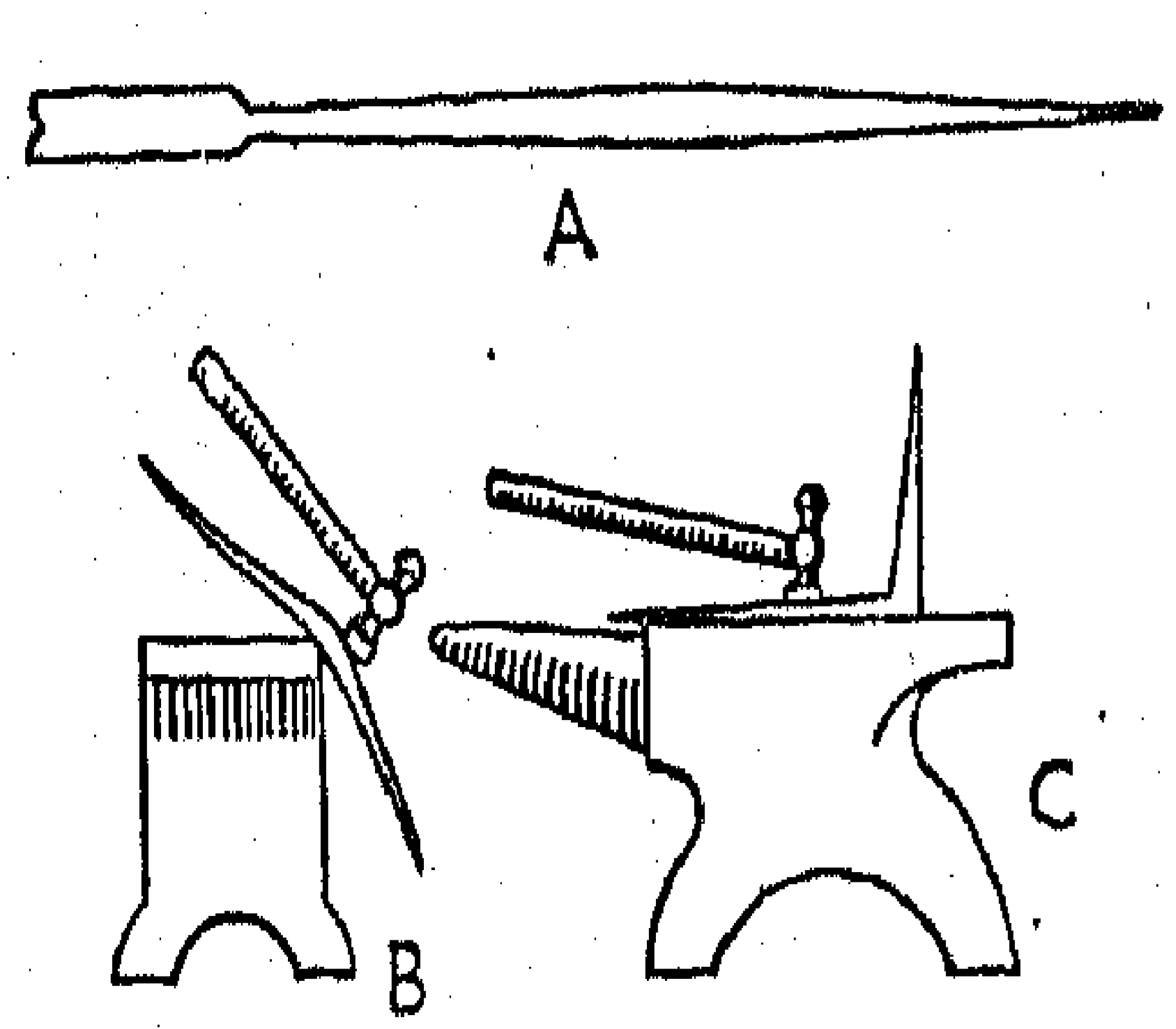


Fig. 10

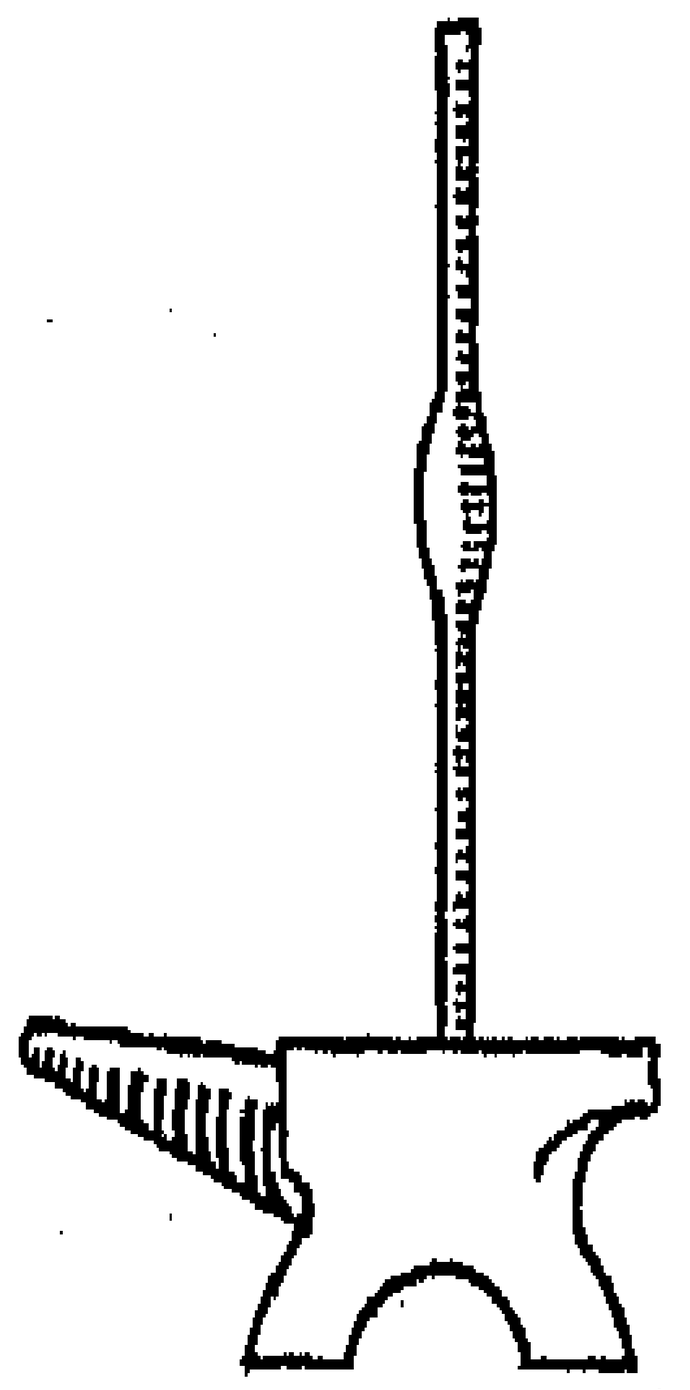


Fig. 11

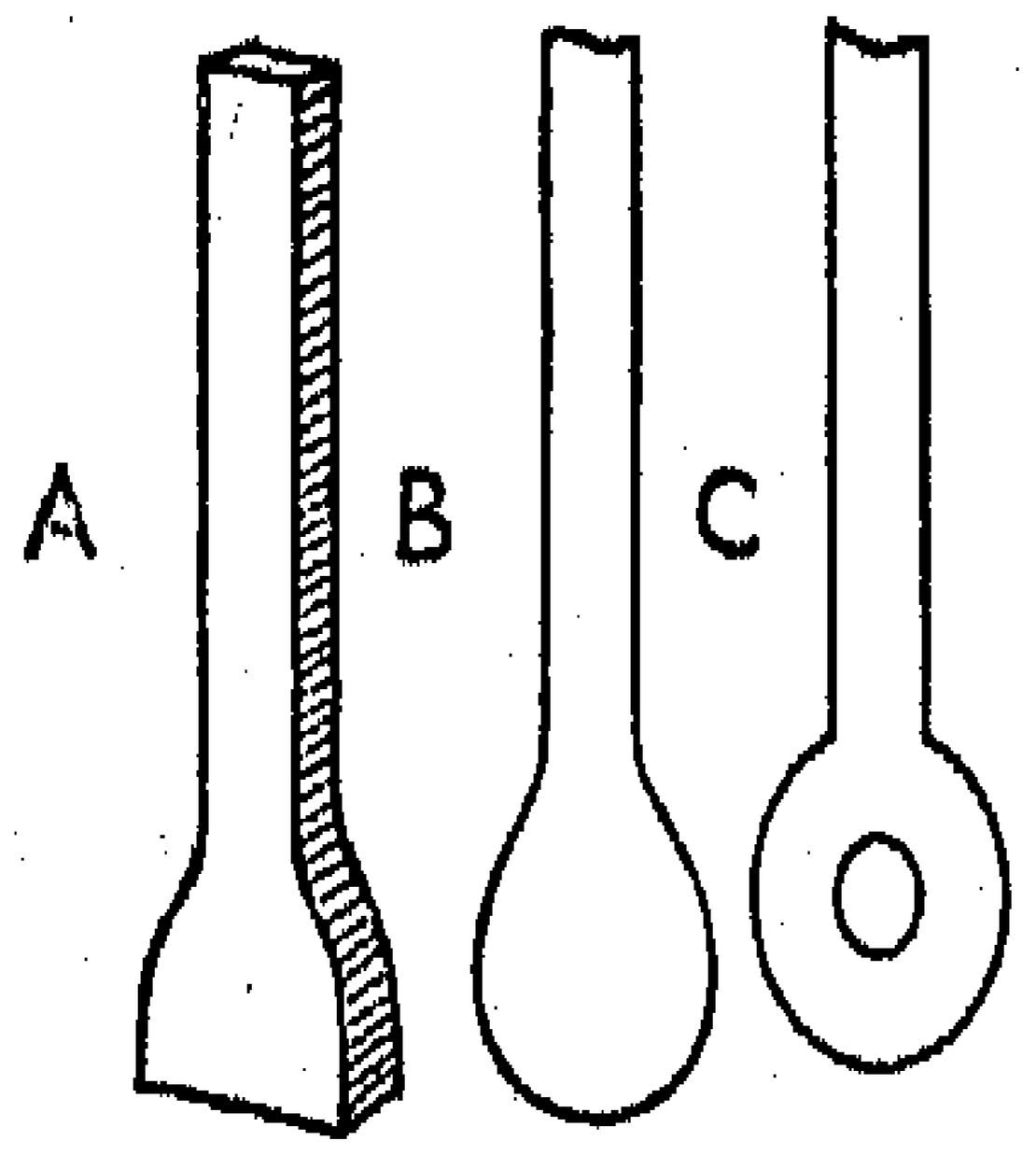


Fig. 12

In making such simple things as brackets, some smithing experience is needed. To make a good job the work should be thick at the bend. Fig. 10 shows the operations in sequence. At A the bar is hammered down to a taper at each end, meanwhile hammering it sideways so as to prevent it spreading in width. It is then bent over the anvil edge by hammering near the middle as at B, and finally it is hammered from the inside of the bend on the top of the anvil as at C, and squared up. Bending always reduces the strength unless the method shown is adopted.

If a head or a shoulder is wanted on a shaft or bar, the metal can be "upset." The easiest way of upsetting the metal is "jumping" it on the anvil. Fig. 11 shows the process. The metal is heated to a good yellow heat at the part where the "swell" is required. When taken from the fire it should be slaked each side of the heated part to confine the heat to where the bulge is to be. This can be done by pouring water over the ends. The bar is then up-ended and jumped up and down vertically on the anvil, which causes the metal to swell out at the hot point. The jumping process should be discontinued as soon as the metal does not appear to swell easily, and the heat should be restored.

A flat bar can be bumped out endways and hammered round to form an eye as shown at Fig. 12. At A it has been jumped up, at B it has been hammered round, at C it has had the hole punched through it while hot. This latter is done by means of a cold, flat-ended punch of taper form, which is driven into the hot metal from one side. If the metal is turned over it will appear dark where the punch has come partly through. As soon as this happens the punch is applied to the dark part and punched down again, the metal being, of course, red hot. The piece is then held over the hole in the anvil, and the punch driven through and out. A taper-punch enlarges the hole, and the metal is flattened and surfaced with blows of the flat peen of the hammer.

Welding is easy if sufficient heat can be obtained. To weld two pieces of iron together they should be jumped up

to give excess of metal, as the subsequent hammering during welding will reduce the cross-sectional area. Fig. 13 shows two forgings as they appear before they are welded together. At A the ends have been jumped up, and at B the ends have been either sliced with a knife tool or driven down, white hot, to an angle on the anvil.

The ends are then placed in the fire together and raised to a welding heat—bright crackly sparks flying from the dazzling white ends. To get the correct welding heat and prevent scale forming, dry sand is sprinkled on the job, which becomes molten, thus keeping the air away and so preventing oxidization, which would prevent the fusion of the two parts together.

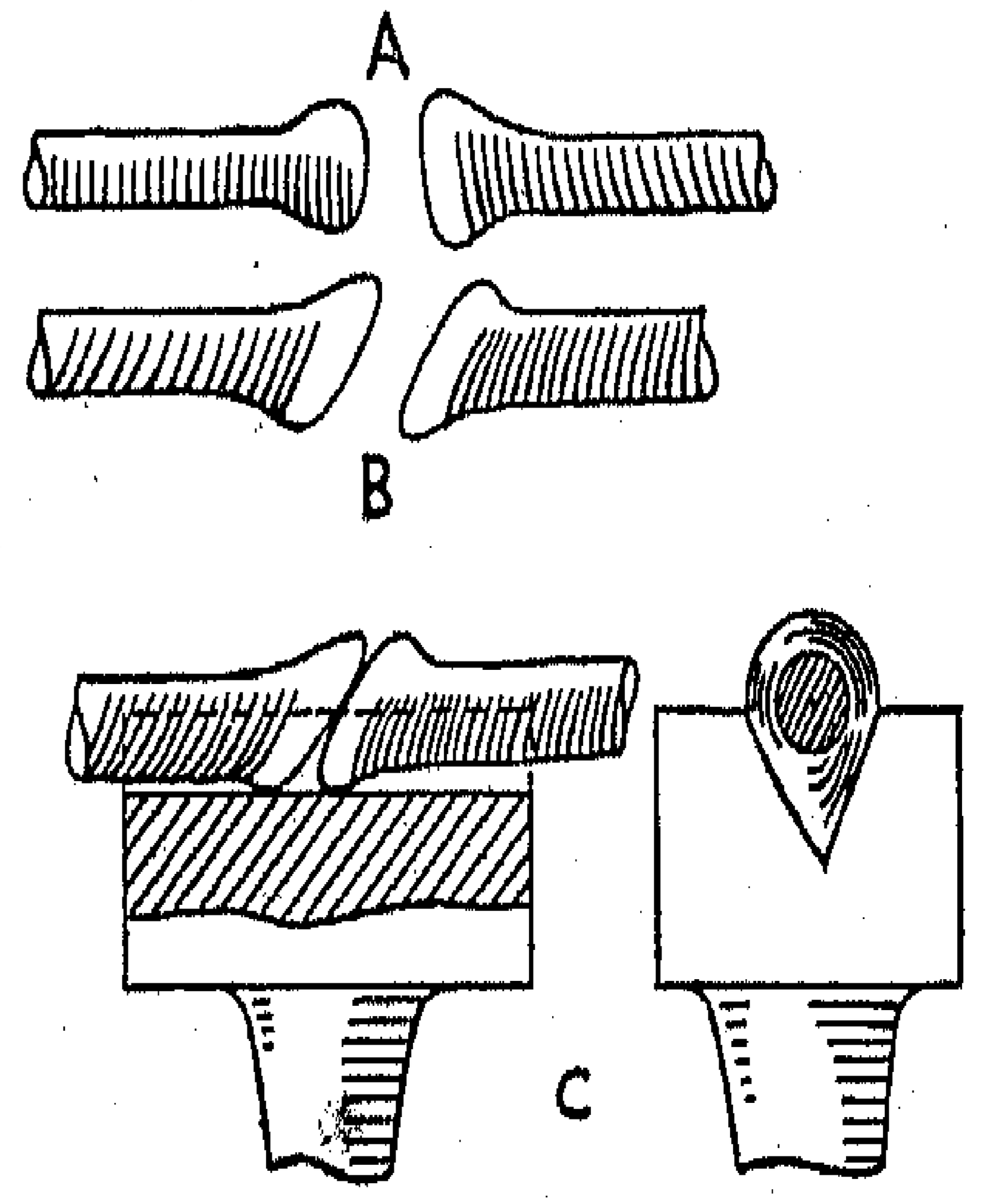


Fig. 13

When both are of a sparkling white heat they are removed, the faces brushed quickly with a wire brush and laid together, in a V block as at C, on the anvil or in a swage block, and quickly hammered down. The faces should be slightly rounded, as shown, so that the first blows consolidate the metal in the middle of the weld. Then they are hammered down as the metal is slowly rotated by hand, the scarfed ends being very carefully closed down while at yellow heat, i.e. before they get red as they will do quickly, since they are the thinnest part of the job and therefore lose heat rapidly.

The job can be finished with top swages or top and bottom hand swages.

The following points will be of assistance in all forging and welding work:

1. Err, if anything, on the side of too much heat. Working at too low a heat cracks and disintegrates the fibre of the iron.
2. Confine the heat to the part to be worked.
3. Brush or knock off all scale before hammering.
4. Build up the metal by jumping wherever the metal has to be worked in a way which would reduce its cross-sectional area.
5. In welding, have a dazzling sparkling heat, get the two pieces together rapidly to prevent oxidization and scale (which would prevent the welding of the metal) and hammer at once.
6. In all forge work keep air from the work when in the fire by building the coal breeze around it.
7. Visualise every operation and its sequence before taking the metal out of the fire, and have all tools, setts, punches, swages, etc., ready at hand so that no second of time is wasted. Do as much at one heat as possible, but stop as soon as the glow gives signs of waning.

SOLDERING

It is impossible to progress very far in metal working without a practical knowledge of soldering, for there are innumerable jobs in the shape of repairing household utensils, motor repairs, model making, and wireless which call for the joining of metals by this process. Indeed, in many cases, soldering is a vital part of the construction of an article.

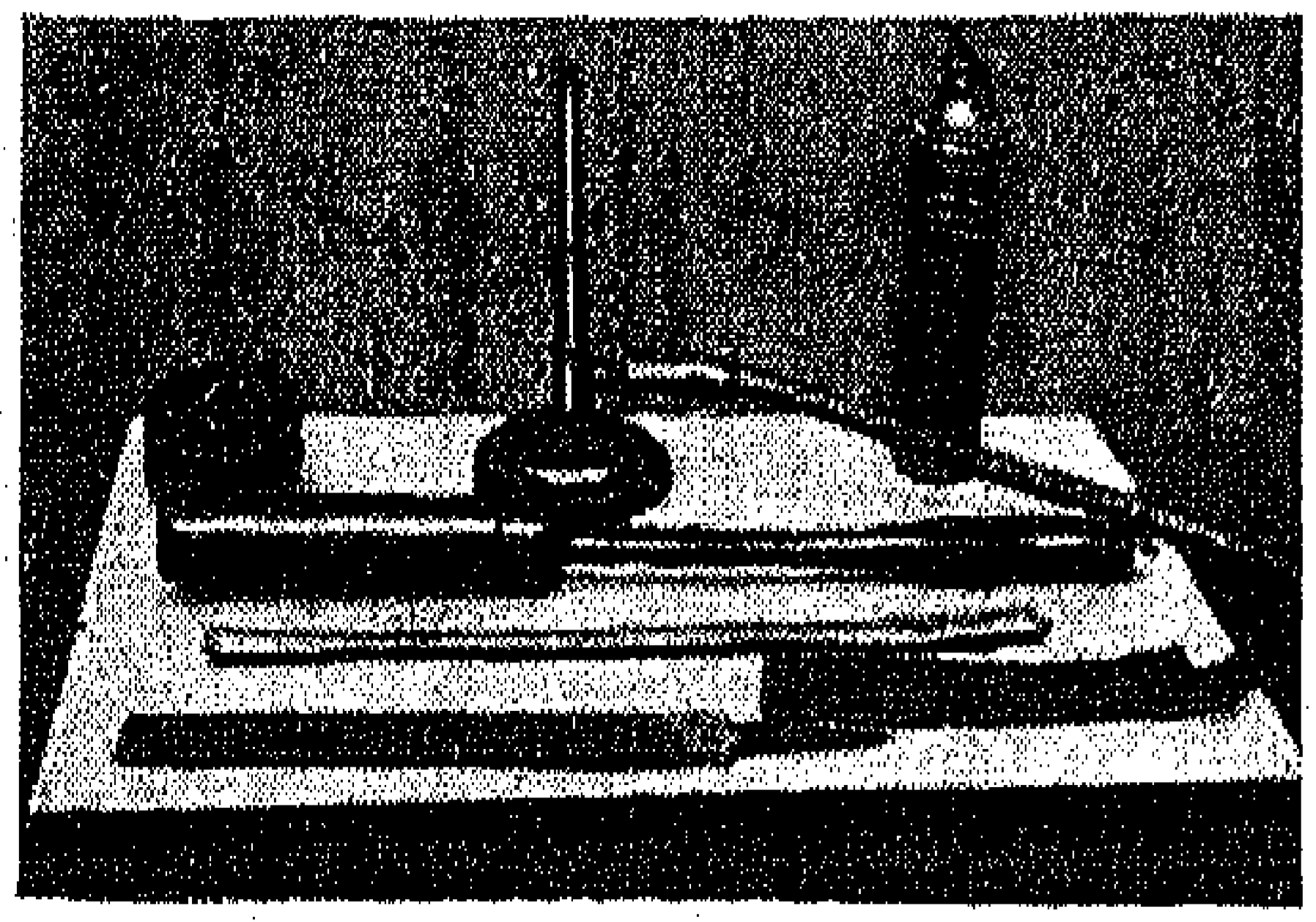


Fig. 1

Briefly stated, soldering is a process of joining metals together by means of an alloy having a lower melting point than the parts to be united.

There are two distinct classes of soldering, known as soft soldering and hard soldering. The former is used where a joint of medium strength is required, and is usually attained by the use of alloys of lead and tin, which have a comparatively low melting point. The latter requires a very much greater degree of heat, and is employed where an exceptionally strong and heat-resisting joint is wanted.

As the majority of jobs the amateur is likely to encounter call for the simple process of soft soldering, this method will be dealt with at some length, while hard soldering, that is, silver soldering and brazing—which necessitates a considerable degree of skill but is only likely to be required for special purposes—will therefore only be briefly surveyed.

The equipment associated with soft soldering, as illustrated in Fig. 1, is inexpensive and consists of the following items:

- Copper bit, commonly called a soldering iron.
- Heating apparatus for heating the bit.
- A supply of tinman's solder.
- A suitable flux.
- Blowpipe for special work.
- File.
- Emery cloth.

Fig. 2 shows a common form of soldering iron suitable for all ordinary purposes. It consists of nothing more than a piece of copper shaped nearly to a point, held by a straight piece of iron terminating in a wooden handle. Its purpose is to hold the heat which causes the solder to melt.

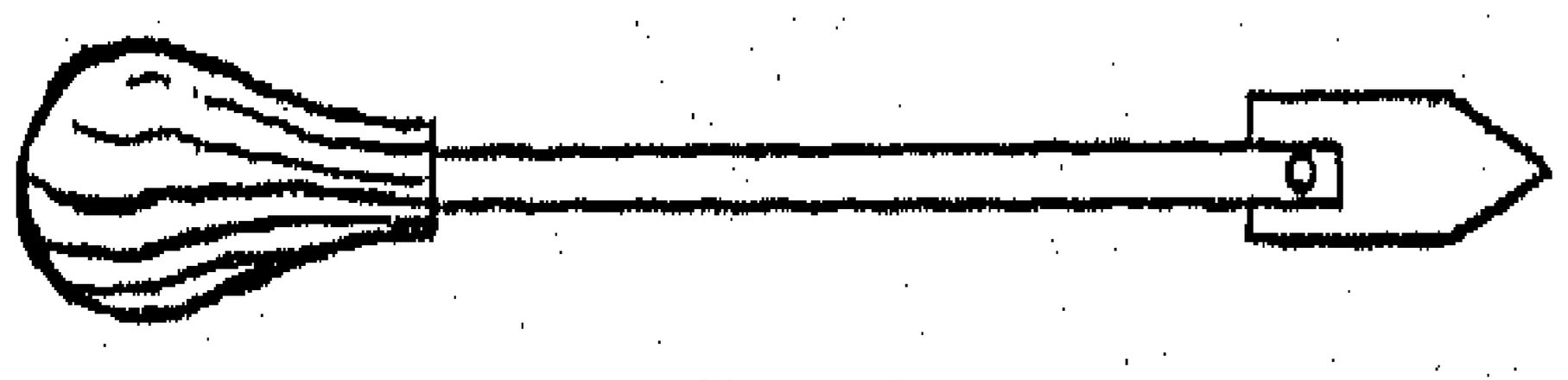


Fig. 2

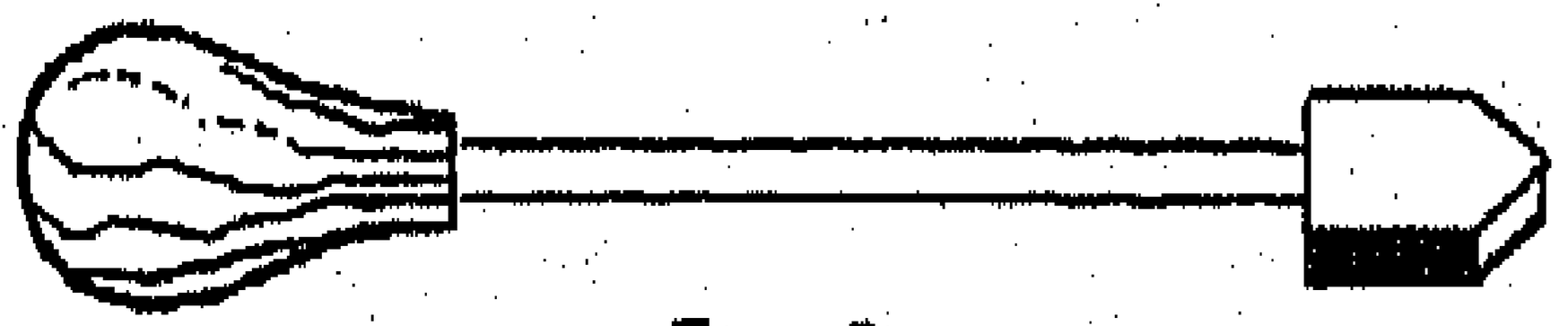


Fig. 3

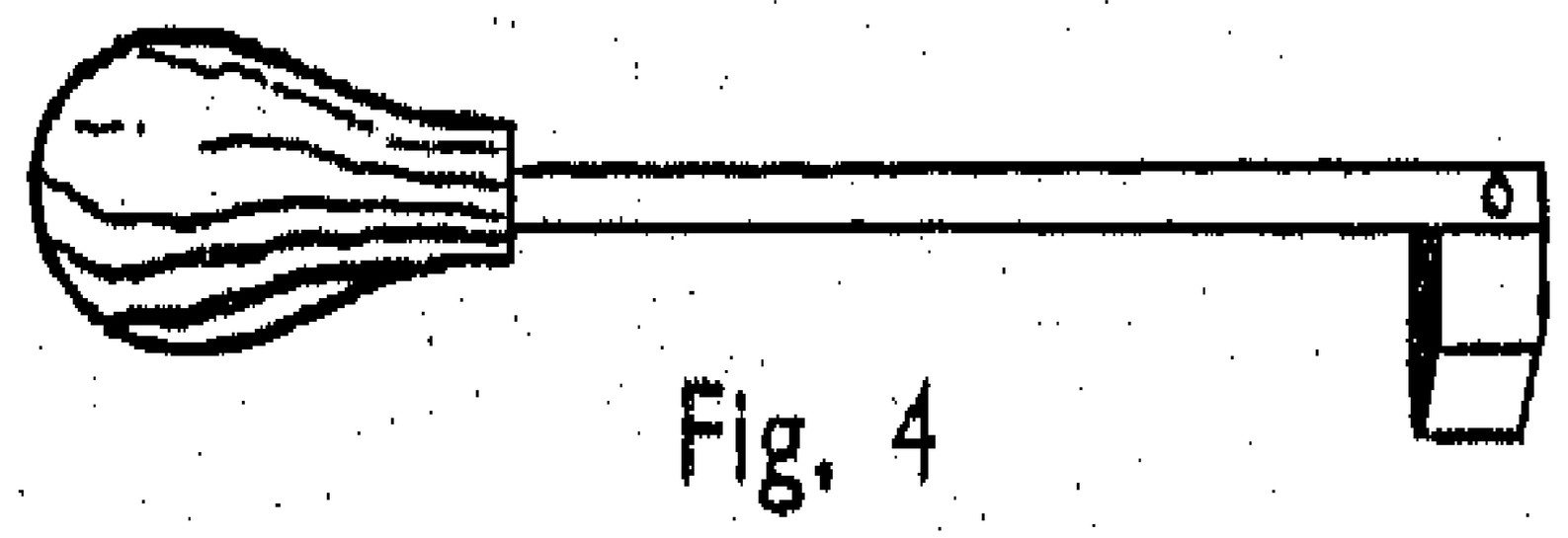


Fig. 4

It is a good plan to have two such bits, one for heavy work and a lighter one for work of a more delicate nature.

Another form of tool is illustrated in Fig. 3, known as a hatchet bit. It is used principally for soldering heavy lead pipes.

For Internal Soldering and for work where great local heat is required, the bit illustrated in Fig. 4 is a convenient tool to use.

If a supply of electric current is available an electric iron with its self-contained heating element is an ideal tool to have, for it rules out the necessity of having a separate heating device associated with ordinary soldering bits. Moreover, absolute cleanliness, so essential to the process, is assured. The type recommended for small work is one consuming about 60 watts, which is equivalent to the energy consumed by a medium-sized lamp. If such an iron is run off the power supply with current at one penny per unit, fifteen hours' service can be obtained for this small sum. The electric soldering-iron is simply plugged into a convenient socket which will heat up the bit to the desired degree in about four or five minutes.

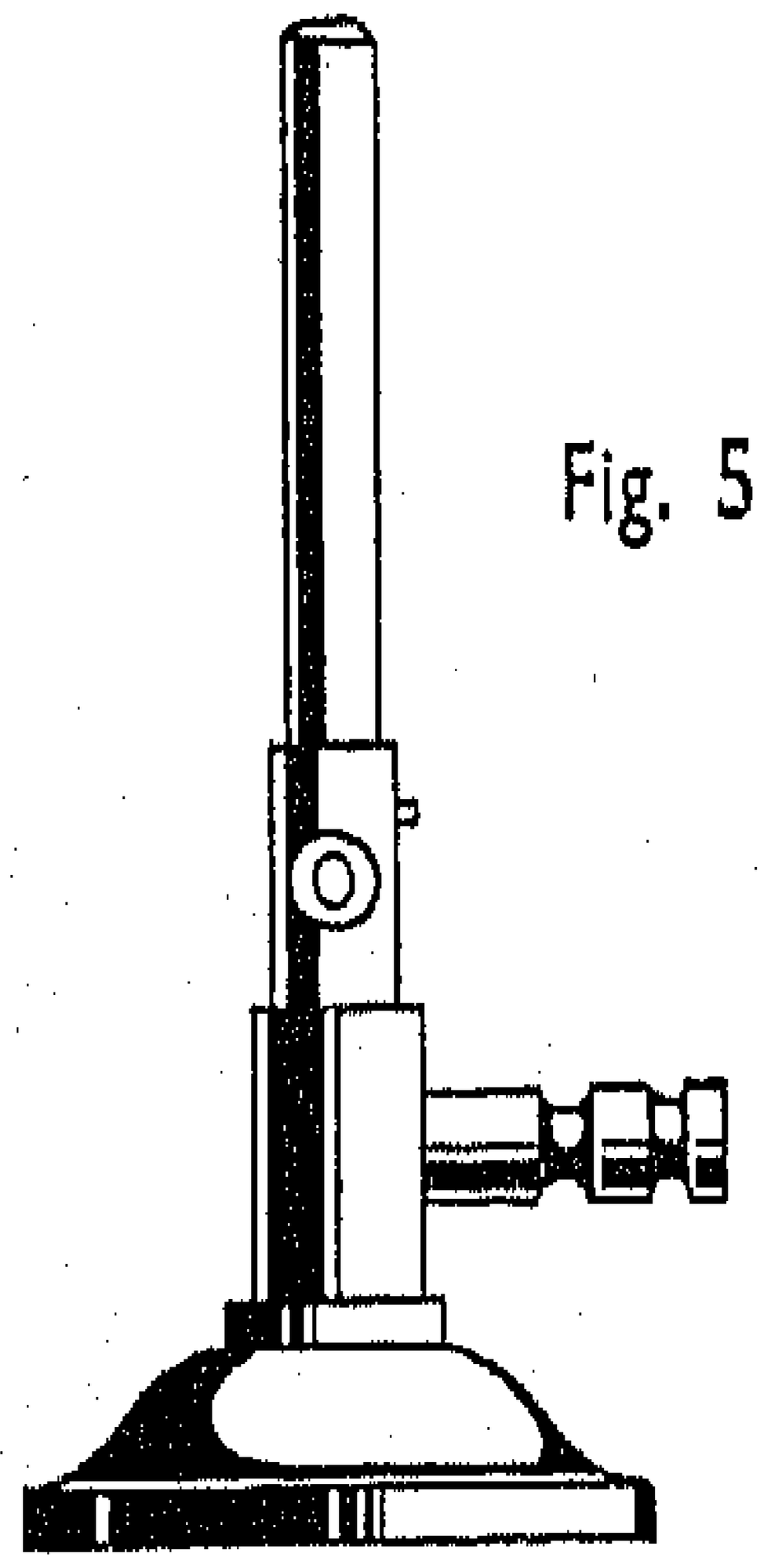


Fig. 5

Assuming that the ordinary copper bit is to be used it is essential to have some means of supplying the necessary heat, and as a coal fire is not always satisfactory, owing to its associated dirt, etc., it is advisable to employ either a Bunsen gas-burner or a petrol or paraffin blow-lamp.

The Bunsen Burner shown in Fig. 5 is particularly good for heating copper bits, as the heat produced is intense and the flame is clean. It is quite a simple device, and consists of a metal tube, at the lower end of which a small gas-jet is provided. Holes are made near this end through which, when the gas is ignited at the top, a draught of air enters the tube by suction. The air mixes with the gas and produces a very hot, non-luminous flame. The air supply can be regulated to the correct degree by turning the loose sleeve fitted for the purpose. It is connected up to the gas supply by means of a flexible tube.

The Petrol Blow-lamp (Fig. 6) gives a very hot flame and heats a copper bit very quickly. It consists of a container for holding the spirit, a Bunsen burner, and a regulating valve.

To operate the lamp it should be filled about three-quarters full of petrol and the filler cap screwed down tight. A small quantity of methylated spirit is then poured into the flanged receptacle which is fitted just below the burner. The spirit is now ignited, and the burner allowed to heat up for a minute or so, the valve, of course, being closed. The regulator is now turned on a trifle, when the tiny spray of petrol vapour issuing from the nipple of the burner will ignite and burn with a bluish flame. If the petrol issues from the jet in the shape of a long smoky flame, it indicates that the petrol has not been sufficiently vaporised and it is therefore necessary to close the valve and heat the burner up again.

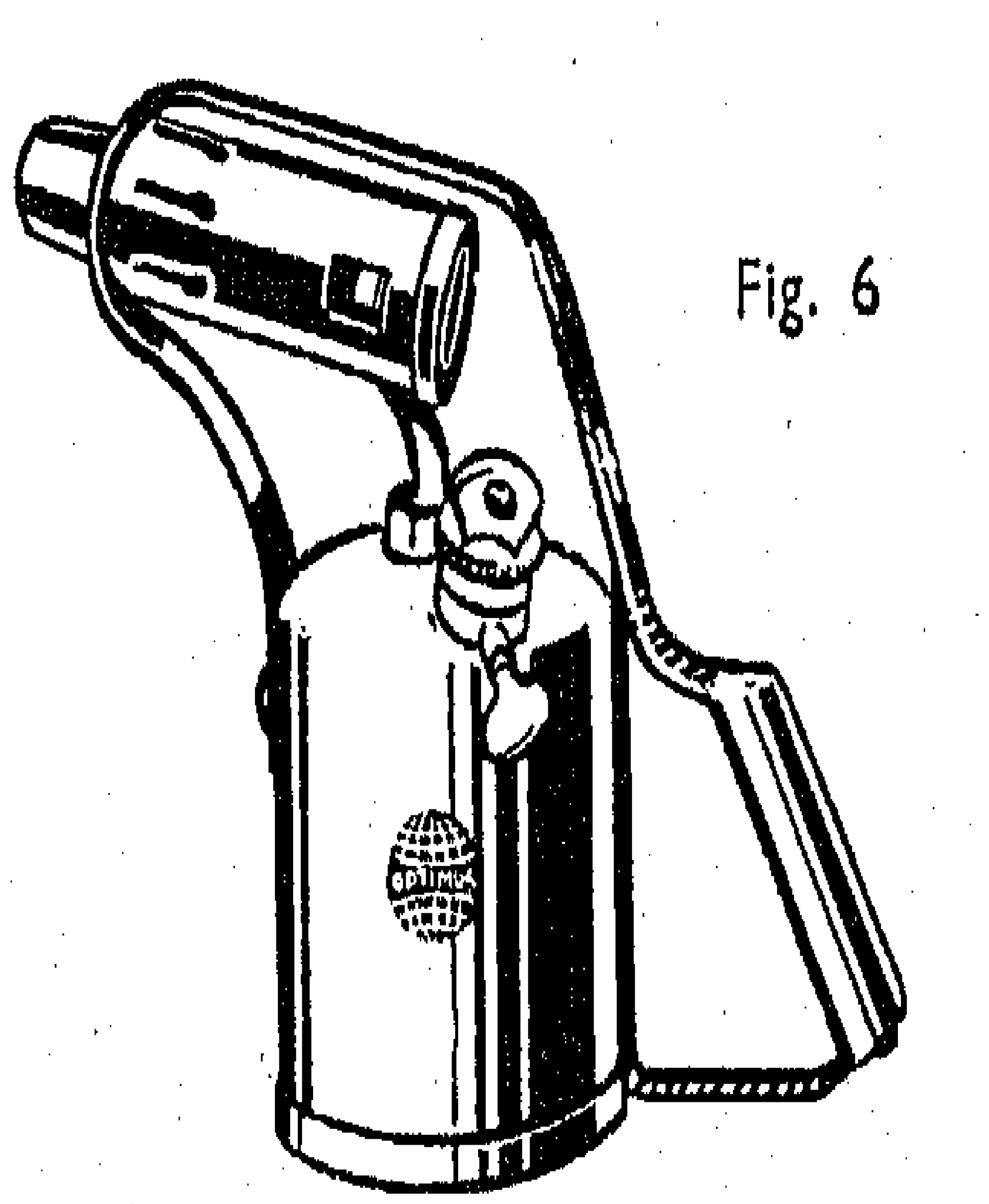


Fig. 6

One of the chief points connected with blow-lamps is that they must always be kept perfectly clean. If the nipple becomes choked the obstruction can usually be dislodged with a small piece of fine steel wire, and should the orifice become too large, due to constant cleaning or any other cause, it must be replaced by a new one, which may be obtained for a few pence at most ironmongers. Owing to the highly inflammable nature of petrol, great care should be exercised to keep all naked lights away when filling the container.

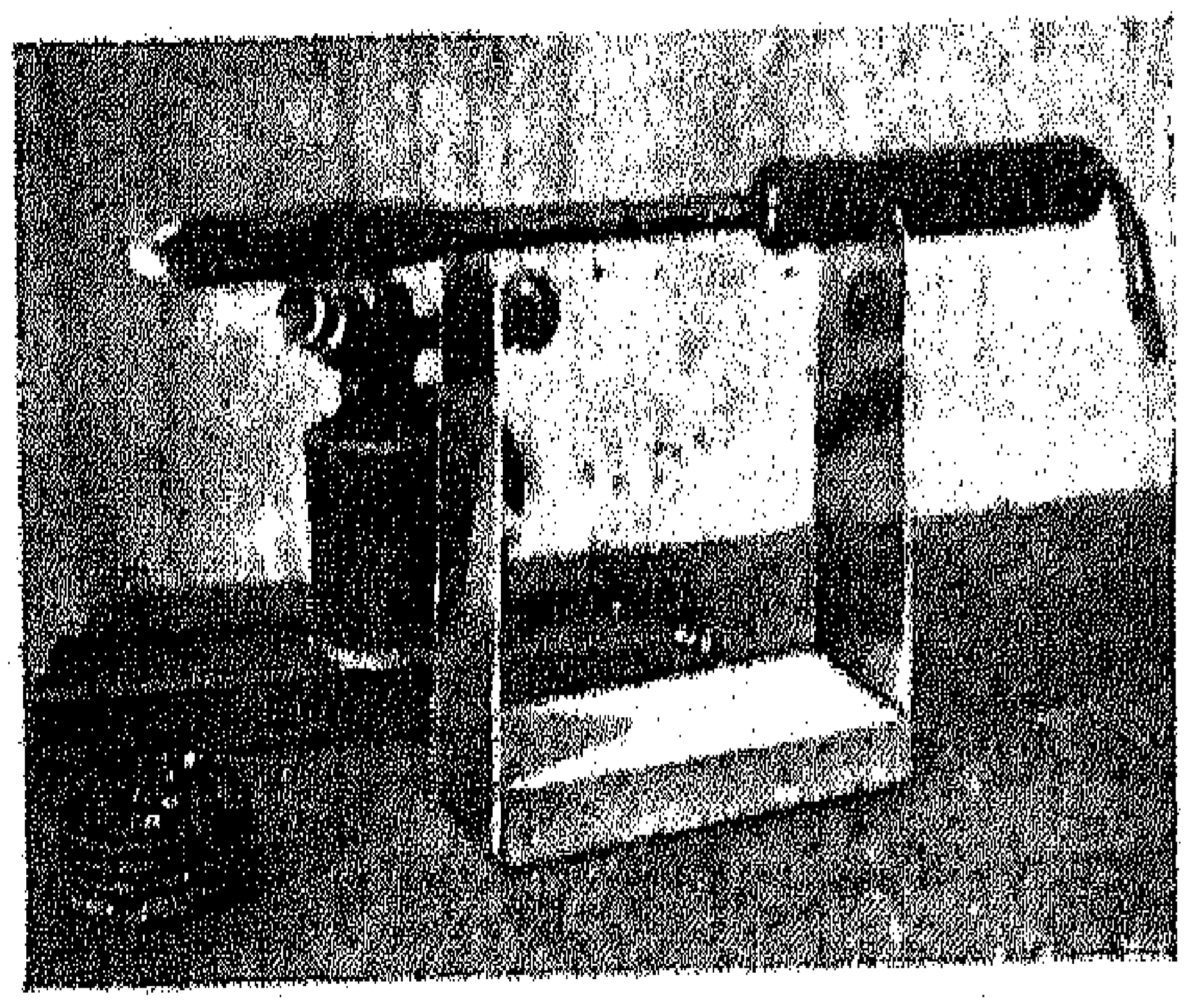


Fig. 7

A Stand for Supporting a Soldering Iron whilst being heated is shown in Fig. 7. It consists of two pieces of stout tinplate, about 3 in. wide, and high enough to allow the business end of the tool to enter the flame of the heating apparatus. A recess is cut in each upper edge to receive the iron shaft of the tool, to keep it in place. The end pieces are then nailed or screwed to a wooden base which should be about 1 in. thick, in the manner shown in the illustration.

If an ordinary household gas-ring is used for heating the tool, the heater should not be placed directly upon a table, but should stand upon a suitable piece of sheet asbestos, otherwise the table may be badly scorched.

A Holder for the Iron that retains heat is a useful accessory for use with an ordinary gas-ring. It is shown in Fig. 8. It can be made from sheet iron bent to shape and fastened with rivets.

Fluxes.—Soldering calls for a suitable "flux" which must be applied to the parts to be joined, to prevent oxidisation of the surfaces.

There are many kinds of fluxes suitable for soft soldering, the principal ones being "killed spirit" (zinc chloride), resin, sal-ammoniac and several proprietary products, including a non-corrosive flux in a convenient paste form. For tinned iron (tinplate), wrought iron, steel, copper and brass, zinc chloride is generally used, but when this flux is employed, any surplus liquid left on the work should be washed away as it is corrosive and likely to have a detrimental effect upon the metals if not so treated. Acid fluxes should therefore not be used upon such work as electrical apparatus, scientific instruments, and objects of a like nature.

Killed spirit is quite easily made if the following instructions are carefully carried out.

Procure a small quantity of commercial spirits of salts (poison) from an oilshop; pour it into a clean earthenware jam jar, and add some clean zinc cuttings. Directly the zinc clippings are immersed in the acid the solution will commence to effervesce and give off dense suffocating fumes. It is therefore better to do this job out of doors where the fumes can pass quickly away. Add zinc bit by bit until the bubbling action stops. Strain off to rid the liquid of surplus zinc, add a pint or two of sal-ammoniac, and when cool place the liquid into a distinctive bottle. Do not forget to label the bottle, and mark it POISON.

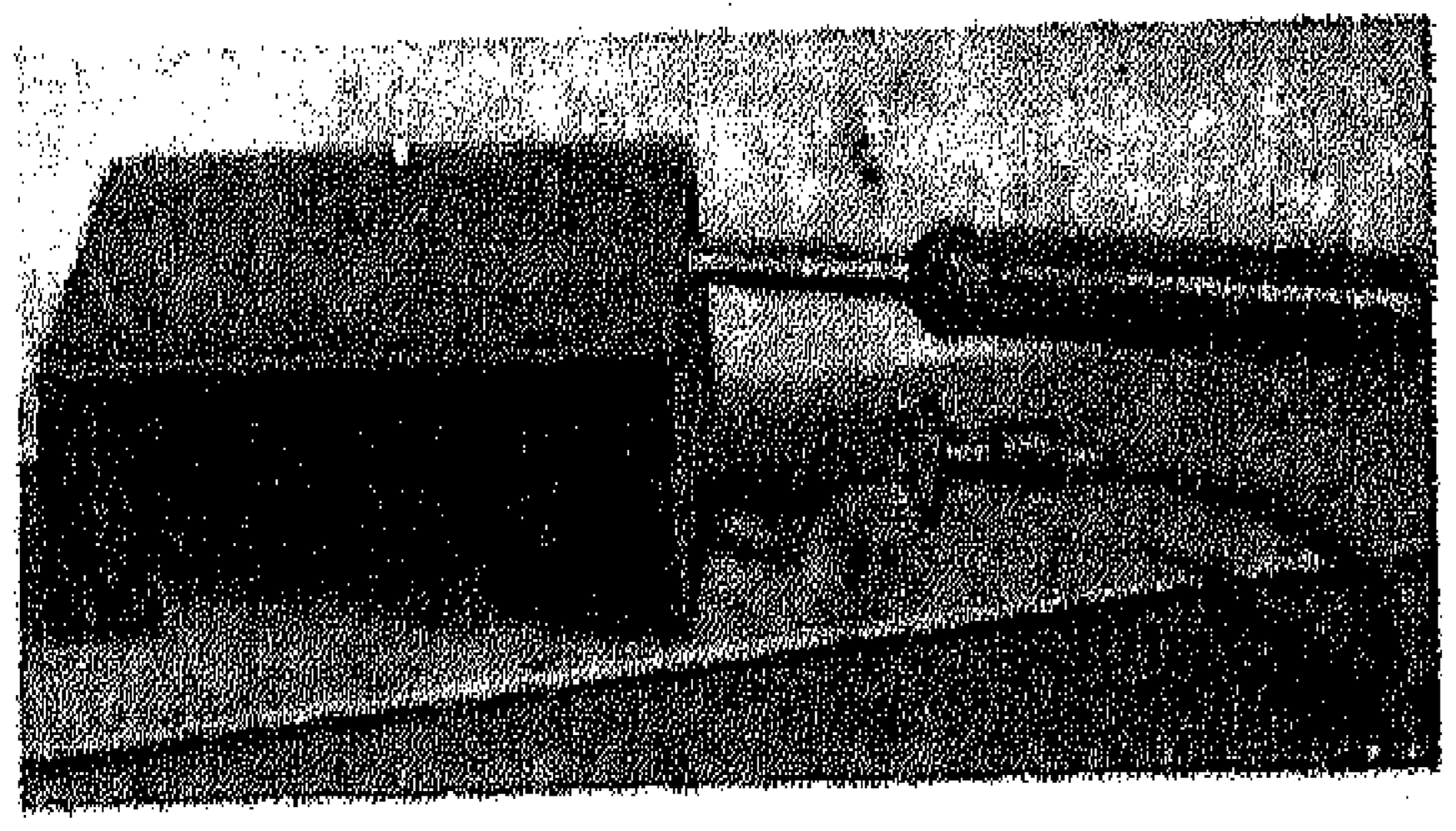


Fig. 8

For soldering zinc, raw spirit of salts is used, but it is essential to wash away all traces of the acid directly the operation is complete, or else the acid will eat right through the zinc.

Suitable fluxes for tin—not to be confused with tinplate, pewter, and lead are tallow, resin, and resin oil.

Ordinary soft solders are alloys of lead and tin. The higher the proportion of tin the lower the melting point. A good-quality solder for use with a copper bit for general purposes should contain one part by weight of lead and two of tin. Such a solder melts at about 350° F. The quality of solder can easily be tested by bending it. If it crackles slightly you may rest assured that the solder is of good quality, that is, there is plenty of tin in its composition. Soft solder is obtainable in two forms, known as wire and bar. Solder in wire form is very convenient for small delicate work, while stick or bar material is useful for larger work.

Solder containing a small proportion of bismuth is useful for soldering pewter, zinc and tin.

Cored Solder, that is, wire solder having a core of a suitable flux such as resin, is very handy where small work is done with the aid of a blow-pipe.

The secret of successful soldering depends almost entirely upon absolute cleanliness of the parts to be joined and the correct temperature of the soldering iron. Before any soldering can be done with a new soldering bit it must be "tinned," which means that a thin film of solder must cover the whole of the lower portion of the bit. The first thing to do when a bit is being used for the first time is to file the faces perfectly smooth. This operation is necessary because the surface of a newly-purchased iron is very often rough and pitted.

To Tin the Bit, pour out some killed spirit into an old saucer or other shallow earthenware pot. Place the bit in the flame of the heater so that the flame impinges upon the thick part of the copper and not on the working end, and heat it up to such a degree that the bit can be held about a couple of inches from your cheek without feeling any discomfort. On no account must the bit be allowed to become red hot, for a full black heat only is required. While the tool is getting hot, cut a piece of tinplate and place a small fragment of solder and a drop of flux in the centre. When the bit is hot enough, clean the surfaces with a smooth file, dip the end of the bit in the flux for a moment, and then melt the solder. Rub each face well in the molten metal until the nose of the bit is completely covered with a thin film of solder. If this operation has been successfully carried out the bit is now ready for use.

Before attempting to do work of any consequence it is a good plan to practise with the bit on different metals in order to get the "hang" of the operation, which, once learned, is seldom forgotten.

For the purpose of describing the process, it will be assumed that it is desired to repair a leaky domestic kettle.

First clean and remove all traces of dirt and grease from the surface to be repaired by rubbing it with fine emery cloth, bearing in mind that this surface should not be touched by the fingers after the cleaning process is done, otherwise the natural grease from the fingers will spoil the surface and thus prevent the solder from adhering. The cleaned surface must now be fluxed. This can be done by applying the flux with a small brush or by using a piece of pointed wood. Heat up the tinned soldering bit to the correct temperature, taking care not to let it get red hot or you will burn off the tin, in which event the bit will have to be re-tinned. When the bit is hot enough, wipe the surfaces quickly with a slightly damp rag and then put the nose of the tool into the flux for an instant. Place the end of the stick of solder on to the point of the bit so that a "blob" or spot of the molten metal sticks to the nose. Next, quickly place the tool to the prepared portion of the work and keep it there until the solder adheres, which, if the bit is sufficiently hot, is a matter of only a few moments. This operation is indicated in Fig. 9. Remove the bit and allow the molten metal to set—which will only take a few moments—and cool off naturally, and then wash off any surplus flux.

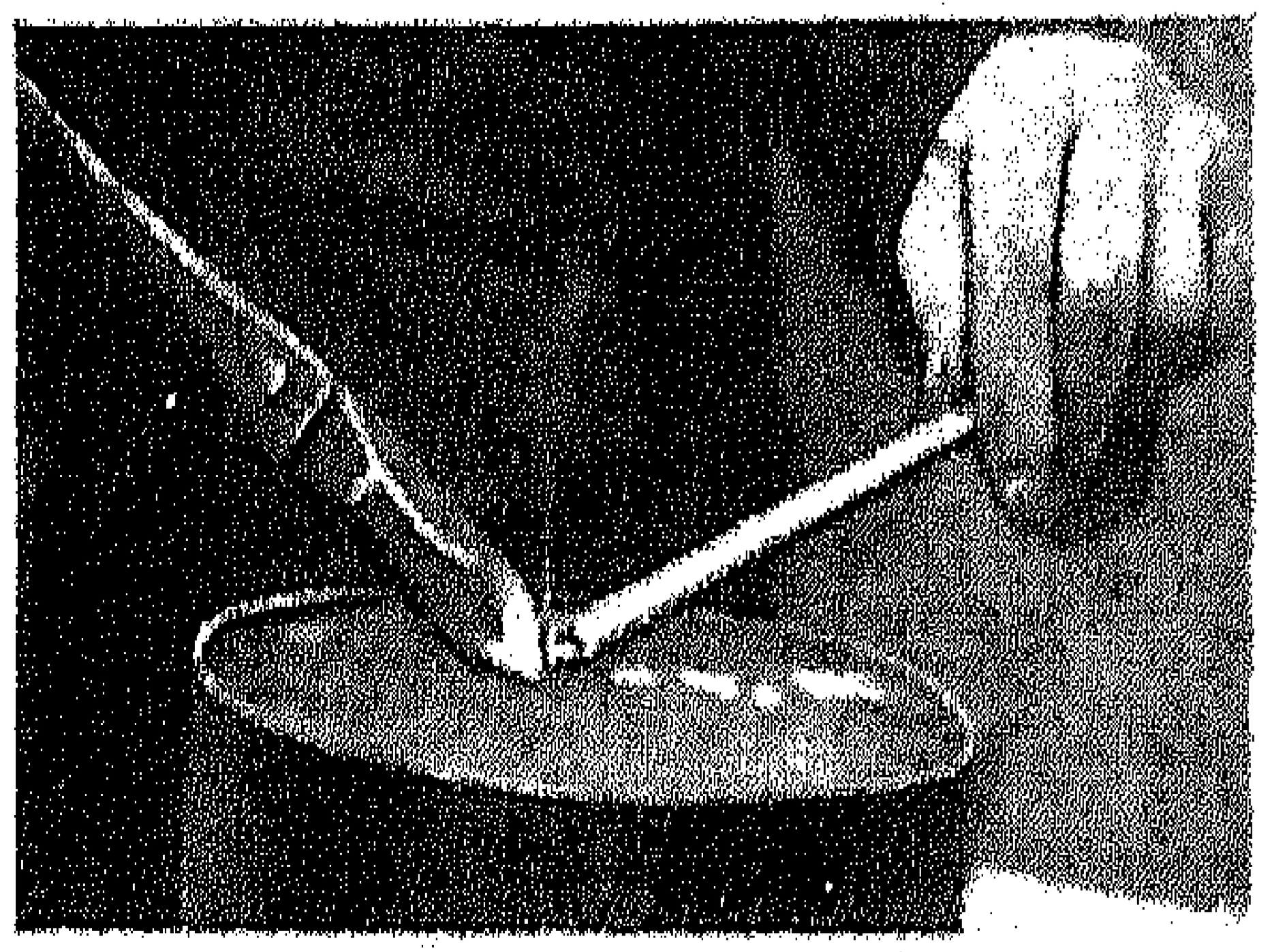


Fig. 9

Another simple example of soft soldered is shown in Fig. 10, where two pieces of sheet brass are required to be joined together by means of a soldering lap joint, that is, a joint where the edge of one piece overlaps the edge of the other. In this case it is necessary first to tin the faces between the joint. Clean and flux the surfaces to be joined in the same manner as that already described. Load the heated bit with solder and run it down the edge and underside of A to form a tinned surface about $\frac{3}{16}$ in. wide. Repeat the operation on the edge and top surface of B, which will complete the tinning process. Place the tinned surfaces together so that the edge of A overlaps that of B by $\frac{1}{4}$ in.; load the bit with solder and apply a spot of solder here and there along the edge to "tack" them together. Then draw the bit and solder very slowly together down the joint, allowing sufficient time to enable the tinned surfaces to unite.

In doing work of this description it is an advantage to tilt the work so that the molten metal will travel downhill with the point of the bit as illustrated in Fig. 11, which clearly shows the operation.

It frequently happens that when working on large objects, sufficient heat cannot be retained by the bit to allow the solder to flow easily, owing to the heat of the bit being rapidly absorbed by the work. In such cases it is necessary first to heat up the work and then proceed in the usual way, when it will be found that the solder will flow normally.

In some jobs it will be found that the use of a soldering iron is impracticable, in which case a small blow-pipe can very often be used to advantage. By means of a blow-pipe and spirit lamp a thin jet of intensely hot and clean flame can be directed on the joint until the solder fuses. This method will be found satisfactory in making joints in lead, tin, etc.

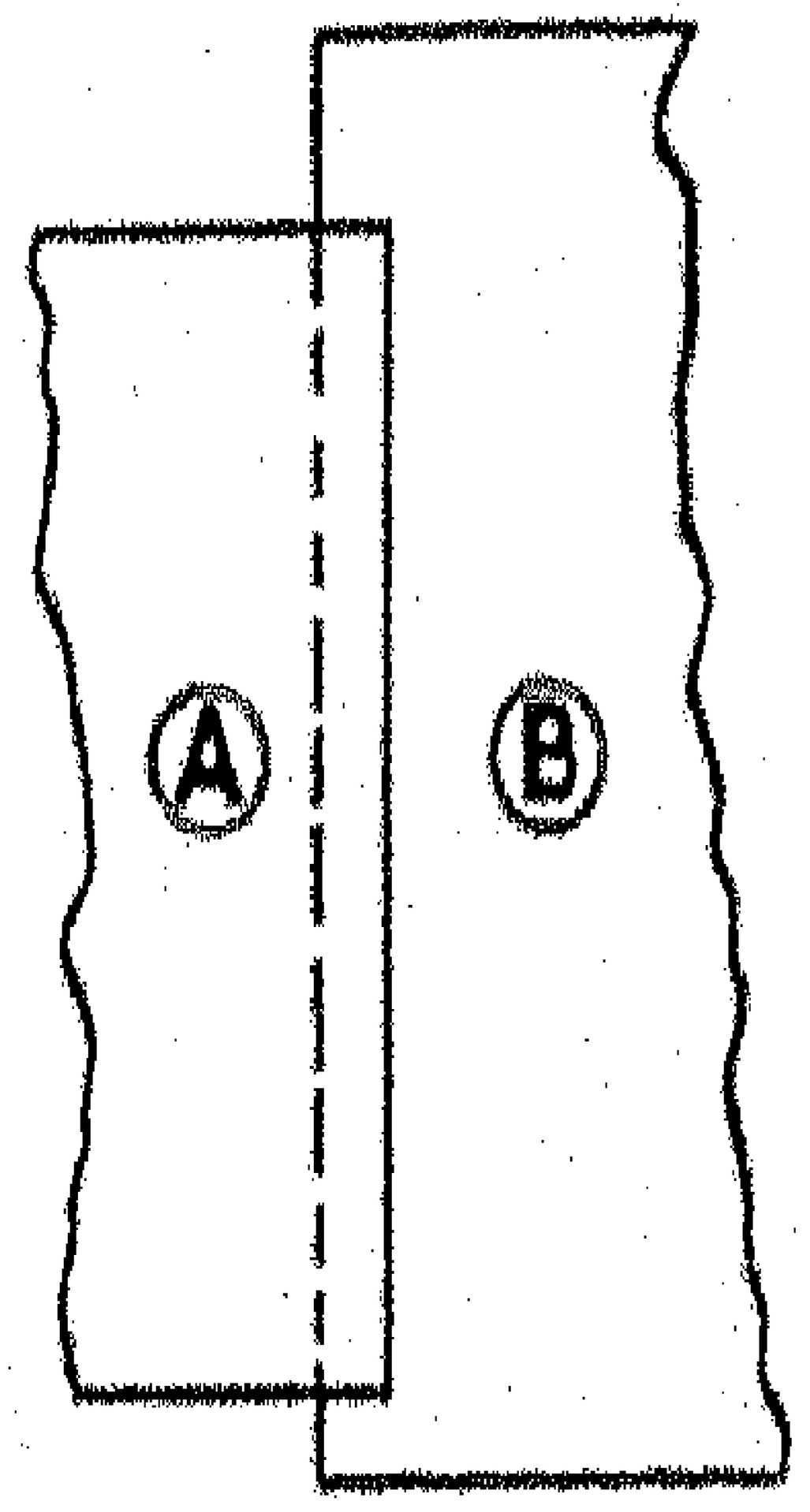


Fig. 10

We now leave the simple process of soft soldering with its comparative weak joint, and pass on to hard soldering, which includes silver soldering and brazing.

Unlike soft soldering, where heat at a comparatively low temperature is usually derived from a copper bit to make the solder run, hard solder requires a much more intense heat applied to the work to effect the same purpose.

Hard Solder, or silver solder, is an alloy of silver and brass, the brass being required to reduce the melting-point. It can be obtained commercially in various thicknesses in either wire or sheet form, and can very often be obtained at a jeweller's or silversmith's shop.

In small work it is usual to support the job on an asbestos or charcoal block in order to conserve the heat.

The flux used is borax, but before being applied to the work it should be prepared as follows. Heat the borax on a clean piece of iron plate over a clear fire or, better still, a Bunsen burner, until it melts. This will get rid of the water with which it is incorporated and leave pure borax. Get a piece of ordinary slate, about 4 in. or so square, and see that it is perfectly clean. Sprinkle a few drops of water on its surface, and mix some of the prepared borax with it to form a semi-liquid of the consistency of thin cream. Thoroughly clean the surfaces to be united, as in soft soldering, and then apply the flux. Cut a small square of solder and place it in position on the work. Now heat the work with a blow-pipe to a bright red heat, but do not allow the flame to play on the solder, otherwise it will melt before the work is hot enough, and consequently will not adhere. When the solder begins to fuse, add more flux and solder, any surplus of which can be removed by a file when the work is cool.

As silver soldering requires a high degree of skill to obtain a satisfactory joint, especially with regard to the application of heat, it is suggested that numerous experiments be made before attempting more important jobs.

Brazing with brass solder, called "spelter," is a reliable method of uniting joints in brass, copper and iron articles. It is not a difficult process to acquire, provided sufficient heat is available. This usually necessitates the use of an iron receptacle containing small blocks of asbestos or pieces of fire-brick to retain the heat. The work is placed in position and the blocks built round it. A powerful blow-lamp will be found useful for supplying the heat. Like other methods of soldering, it is absolutely necessary thoroughly to clean the surfaces to be joined. This is best done with a file and then finishing off with emery cloth. A borax flux is used as in silver soldering, and a plentiful supply should be applied to the joint.

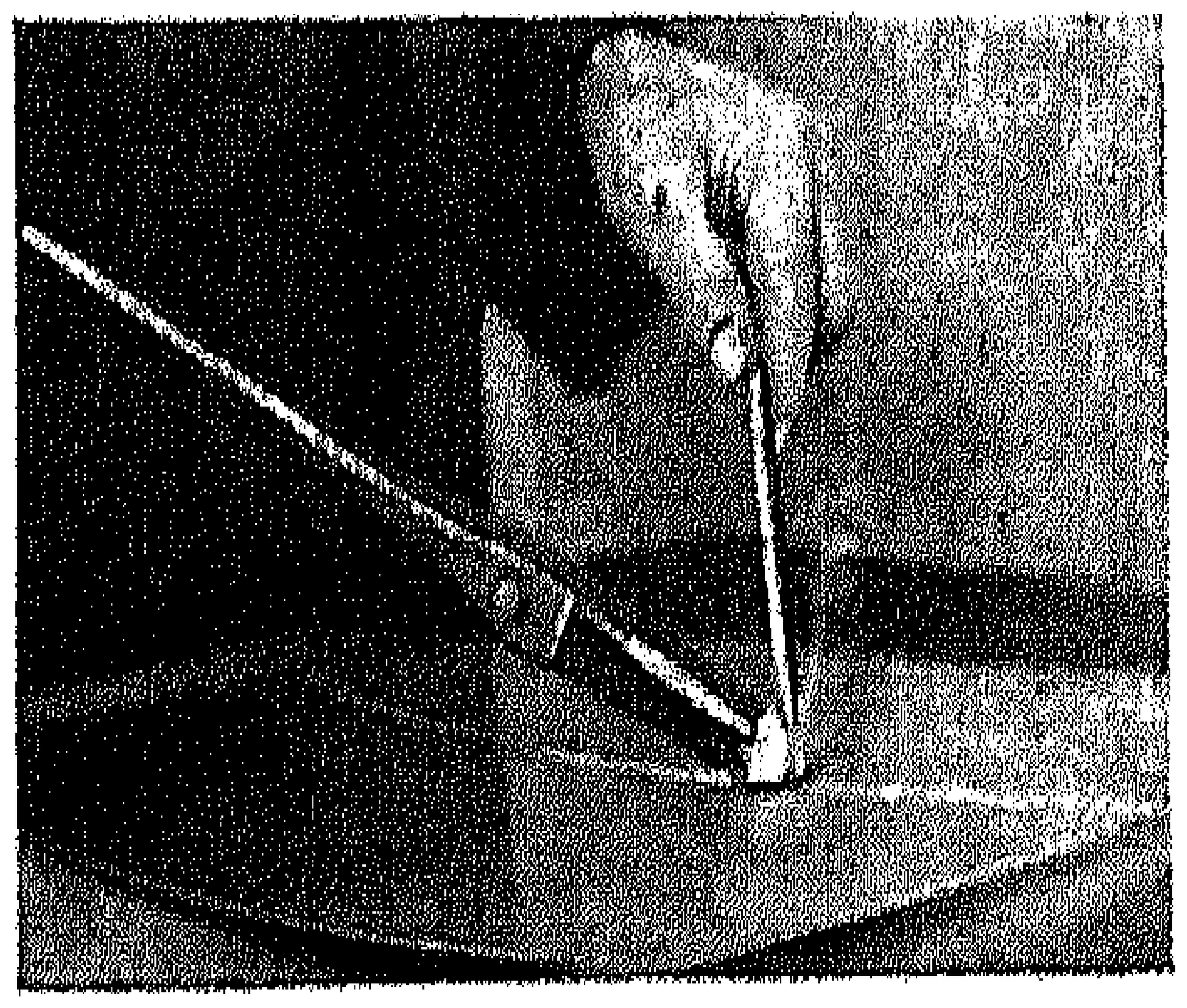


Fig. 11

Direct the flame on the flux for a moment to get rid of the moisture, and then heat up the work to a white heat, but if the work is thin, take great care not to burn it. Dip the end of a stick of spelter in the flux and apply it all round the part to be united. When the spelter is seen to run, cut off the heat and allow the work to cool.

The small asbestos blocks previously referred to are made from pure asbestos. Pieces of asbestos-cement sheeting or tiles should not be used as they simply fly to bits when subjected to the intense heat from a blow-lamp.

HARDENING AND TEMPERING

The tempering of steel for tools, etc., and the hardening of iron and steel for parts of mechanism which are subject to much wear—such as the cups and cones of ball bearings—are operations which can be easily accomplished by the amateur, and if proper precautions and procedure are adopted, good results can be obtained.

The process of hardening will be dealt with first.

In the case of cast steel or carbon tool steel, as it is often called, the hardening merely consists in heating the material to a bright red heat and plunging it into clean, cold water. This will make it "dead" hard and extremely brittle. Consequently it will easily crack and break, and therefore be useless for tools.

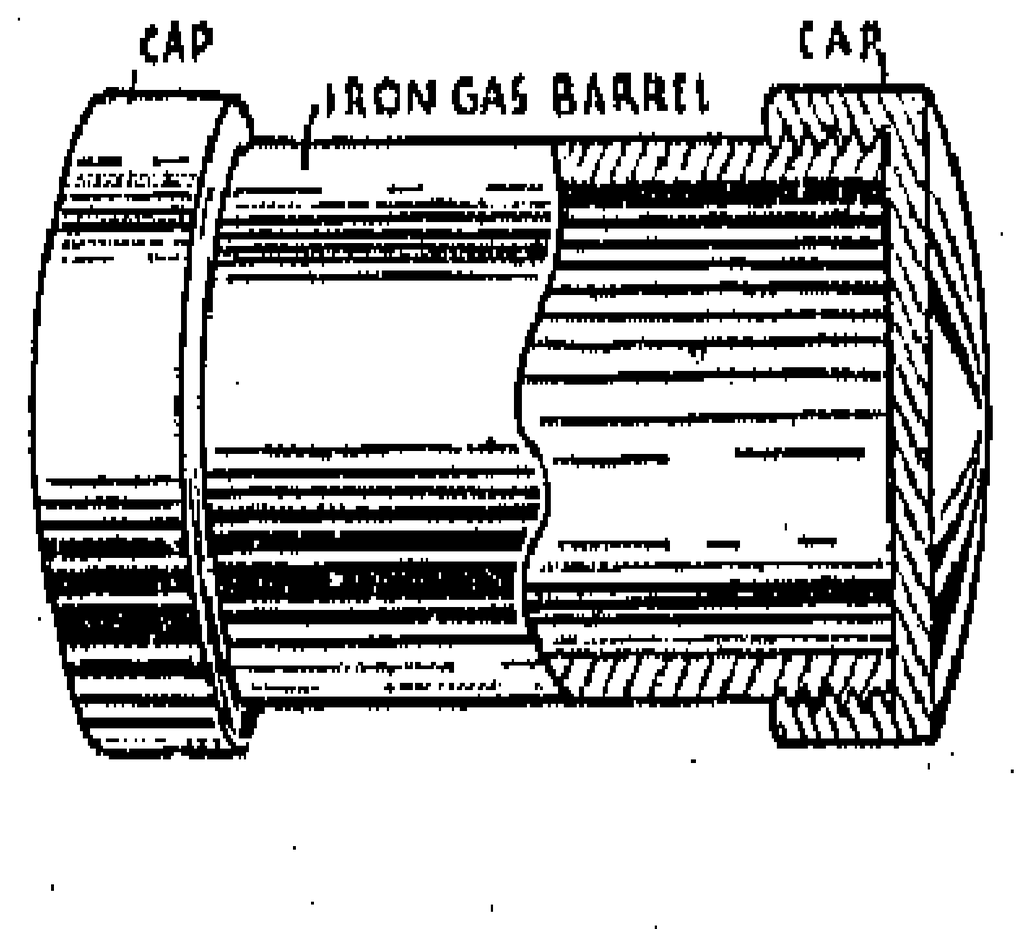


Fig. 1

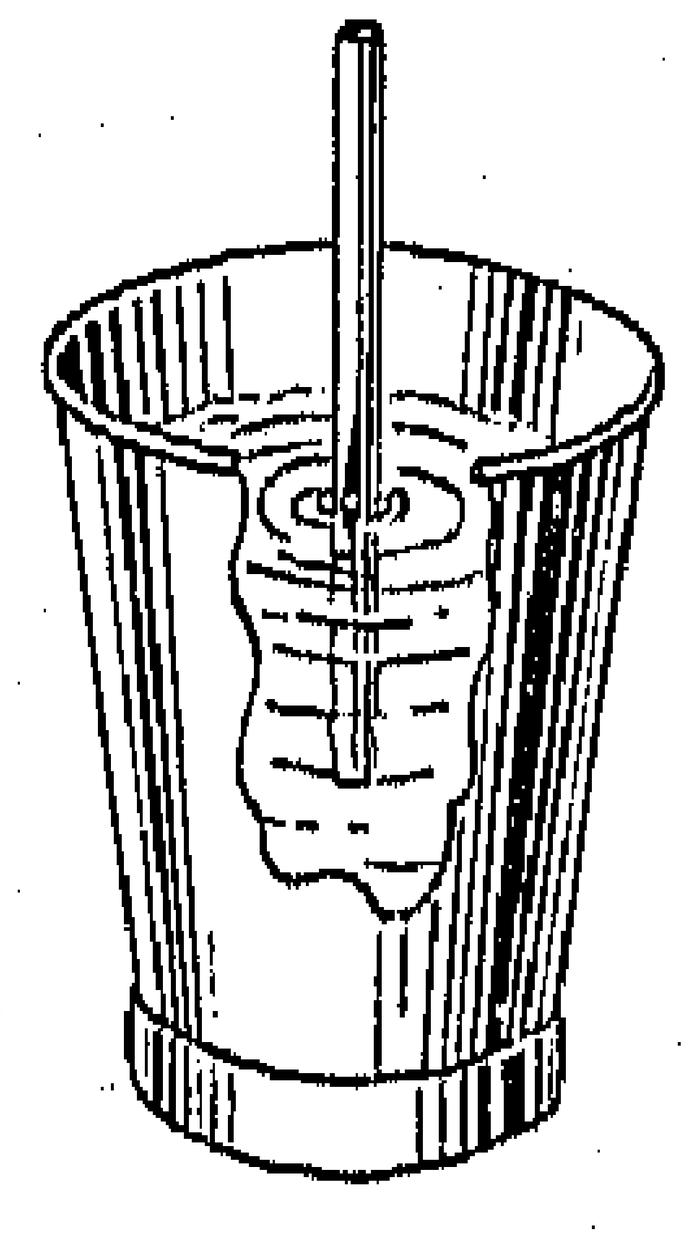


Fig. 2

Indeed, there are very few occasions where dead-hard steel can be used. To render it suitable for use it must be "tempered," or, in other words, the hardness must be reduced to a point where the metal will be sufficiently strong to withstand the shock of cutting the material for which it is intended, and yet be hard enough not to be easily blunted in use.

Mild steel and wrought iron cannot be hardened by heating and suddenly cooling, because they have not sufficient carbon in their constituents. Both of these metals must have carbon added to them before they can be made hard, and they cannot—except in expensive muffle furnaces—be hardened right through as in the case of cast steel, but only to a small depth from the surface.

Case - hardening.—This kind of hardening, rendered possible by the addition of carbon to mild steel or to wrought iron, is known as "case-hardening."

To add the extra carbon to the metal it is necessary to heat the metal in contact with the carbon to a very high degree of temperature. This can be easily done by enclosing the article to be treated in a piece of gas barrel charged with bone dust, scraps of leather, etc. (as illustrated in Fig. 1), and heating it to the right degree. The bone dust and leather become calcined by the heat, and the glowing iron, having an affinity for the carbon contained in the bone or leather, absorbs it into its surface.

The length of time during which the glowing metal remains in contact with the carbon determines the depth to which the carbon is absorbed into the surface of the metal. Four or five hours would give a depth of about $\frac{1}{16}$in. The iron actually assumes a "casing" of steel, and this casing may be hardened by heating the material to a red heat and plunging it into cold water, in the same way as hardening cast steel, but with this difference—the core of the metal will remain soft.

There is no need to temper the hardened surface, because the piece cannot crack, if certain precautions are taken, on account of the mass of comparatively soft metal within.

The heating of the metal in contact with the carbon (bone dust, etc.) must be very thorough.

If the work is urgently required, cooling may be done at once by tipping the contents of the red-hot receptacle into cold water, but if time is of no consequence, a better way is to let the whole cool down gradually, when the metal (core and case) will be quite soft. Its surface can then be hardened by heating to a full cherry-red and plunging it into cold water.

Kasenit.—To avoid the necessity of packing the metal in bone dust and heating it in an iron receptacle, case-hardening to a lesser depth may be carried out by the use of a hardening compound known as Kasenit. This substance is in the form of a powder which is sprinkled on the red-hot iron while in the forge or under the influence of the blow-pipe. The Kasenit immediately melts on the surface of the iron and seems to be absorbed by it.

The process should be continuous, keeping the metal glowing hot and ladling the Kasenit powder on with a flattened rod, as one would apply spelter in brazing. After this treatment has been carried out for, say, twenty minutes to half an hour, the metal, still red hot, should be plunged into a bucket of clean, cold water to which a handful or so of salt has been added.

Kasenit is one of the most useful materials for amateur use. By its aid small screws as well as larger parts can be easily and quickly case-hardened, and as there is practically no distortion, a piece of iron or mild steel can be turned or otherwise shaped to finished size and hardened afterwards.

An important point to be observed when carrying out hardening and case-hardening is that the red-hot metal must always be immersed end-first. Failure to take this precaution will generally result in warped and bent material when cool. If the article is case-hardened the "casing" will crack on the outside of a curve. Fig. 2 shows the correct method.

Always use a large-sized bucket or similar circular vessel, so as to have a sufficient volume of water to prevent its temperature rising quickly. Swirl the water round and plunge the article being treated in the vortex. This will ensure a constant surface contact of fresh water on the piece being cooled.

As previously mentioned, dead-hard cast steel is practically useless unless it has been tempered, that is to say, its hardness reduced to a degree consistent with strength.

Tempering is done by re-heating the metal after hardening until it assumes a colour which would indicate the degree of hardness suitable for the work, and then quenching it in water.

Take a lathe tool, for example. It is first heated up to a bright red colour and then plunged into cold water, which hardens it. The next process is to clean the surfaces quite bright with a piece of pumice stone or with emery cloth. Then take a blow-pipe or a blow-lamp and apply the flame to the shank of the tool at a point about midway between the two ends. A colour will be seen to creep gradually up the tool from the part being heated. First it will be a light straw colour, then a golden yellow, and as the temperature increases, a dark brown, followed by purple and blue. These colours gradually follow one another from the heated part to the end of the tool. Observe the colour-changes carefully and when the dark straw hue reaches the cutting-edge, quench the tool quickly in clean, cold water.

If a chipping chisel is being tempered, let the colour continue up the tool until a straw-purple colour reaches the cutting end and then quench.

Quenching at a very light colour will give a very hard tool, with a tendency to brittleness; a full golden yellow gives a hard tool sufficiently tough to prevent breakage, and is the most useful temper for metal-working tools for cutting.

Woodworking tools may be "let down," as the process is called, to a yellowy-purple or brown colour. They need not be so hard as metal-working tools, and hold a finer edge at this temper, and will hone up on the oilstone, forming a "wire edge," which is the correct thing for plane-irons, firmer- and mortice-chisels, gouges, etc.

When tempering steel, avoid direct sunlight on the work, as it prevents one seeing the colour-changes accurately. A shady corner of the workshop is obviously the best for this kind of work.

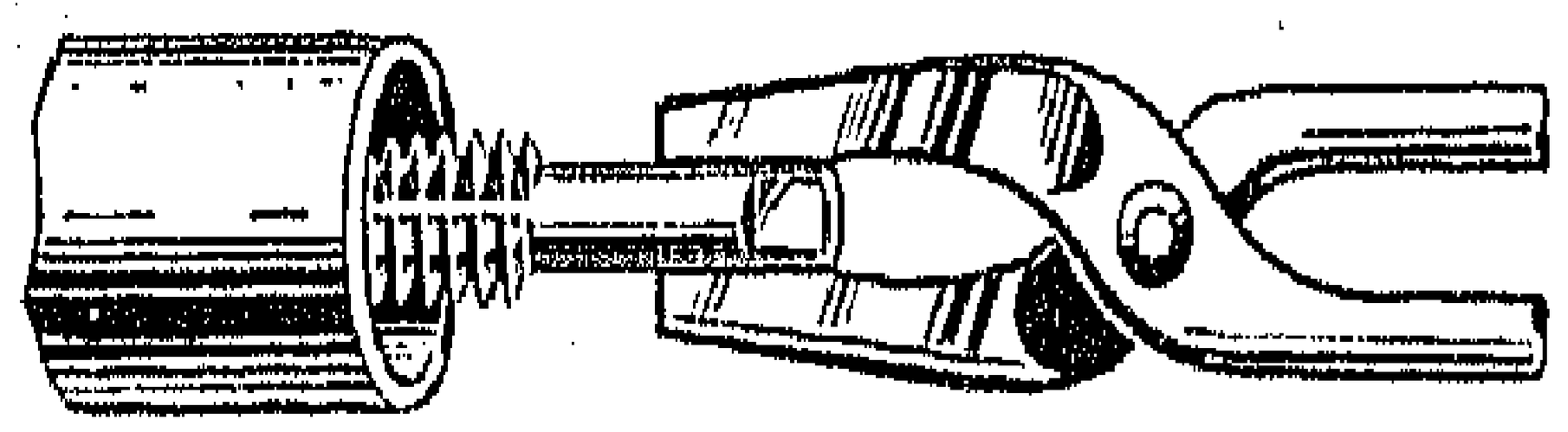


Fig. 3

In the case of hardening taps, reamers, etc., where the cutting-edges are formed along the greater portion of their lengths, the best way to "draw the colour" is to make the tool dead-hard by quenching in a swirl of water as described and, having brightened it all over, to insert it in a piece of iron gas-barrel previously heated to a dull red heat. The tool should be held inside the tube with a pair of pliers, moving it backwards and forwards down the centre, but on no account allowing it to touch the wall of the tube. An illustration of this appears in Fig. 3.

The tool should be withdrawn occasionally to test the colour, and when the whole of the cutting-teeth assume a deep straw colour, the tool should be quenched.

A convenient method of tempering a screw-die is to hold the die by a pair of tongs or pliers over a red-hot piece of flat iron and keep turning the tool over. The die, having been polished, should be held at a distance of about $\frac{3}{16}$ in. away from the hot bar. When the colour assumes a very deep gold, nearly approximating purple, on each side, it should be quenched quickly by immersing it, flat side downwards, in cold water.

Another convenient method of tempering is to immerse the piece in molten lead, drawing it out occasionally for inspection till the required colour is obtained, and then quenching.

Quenching Colours.—The following is a short list of colours at which to quench when tempering various tools:

Taps and dies—full golden yellow.
Reamers—light golden yellow.
Lathe tools—golden yellow.
Wood chisels—gold with a touch of purple.
Plane irons—gold with a touch of purple.
Punches—purple.
Cold chisels—purple.
Knives—light blue.
Screwdrivers—dark blue.

For small tools such as the little cutters used in lathe-tool holders, a method which eliminates ordinary tempering is to heat the tool to a cherry-red colour and then swirl it in a bath composed of the following:

1 gallon rain or distilled water.
1 oz. cyanide of potassium (poison).
8 oz. saltpetre.
3 oz. lime.
Small pinch of permanganate of potash.

Pieces hardened in this way are very tough, will withstand considerable pressure before breaking and will take a good cutting-edge.

SHAFTING AND PULLEYS

WHERE a workshop is equipped with several machine tools, such as a lathe, drilling machine, universal woodworking machine, hack saw, circular saw, band saw—or any three or four of these machines—it becomes convenient to arrange shafting and pulleys so that a gas engine, an oil engine, or an electric motor can be employed to drive the plant or any part of it.

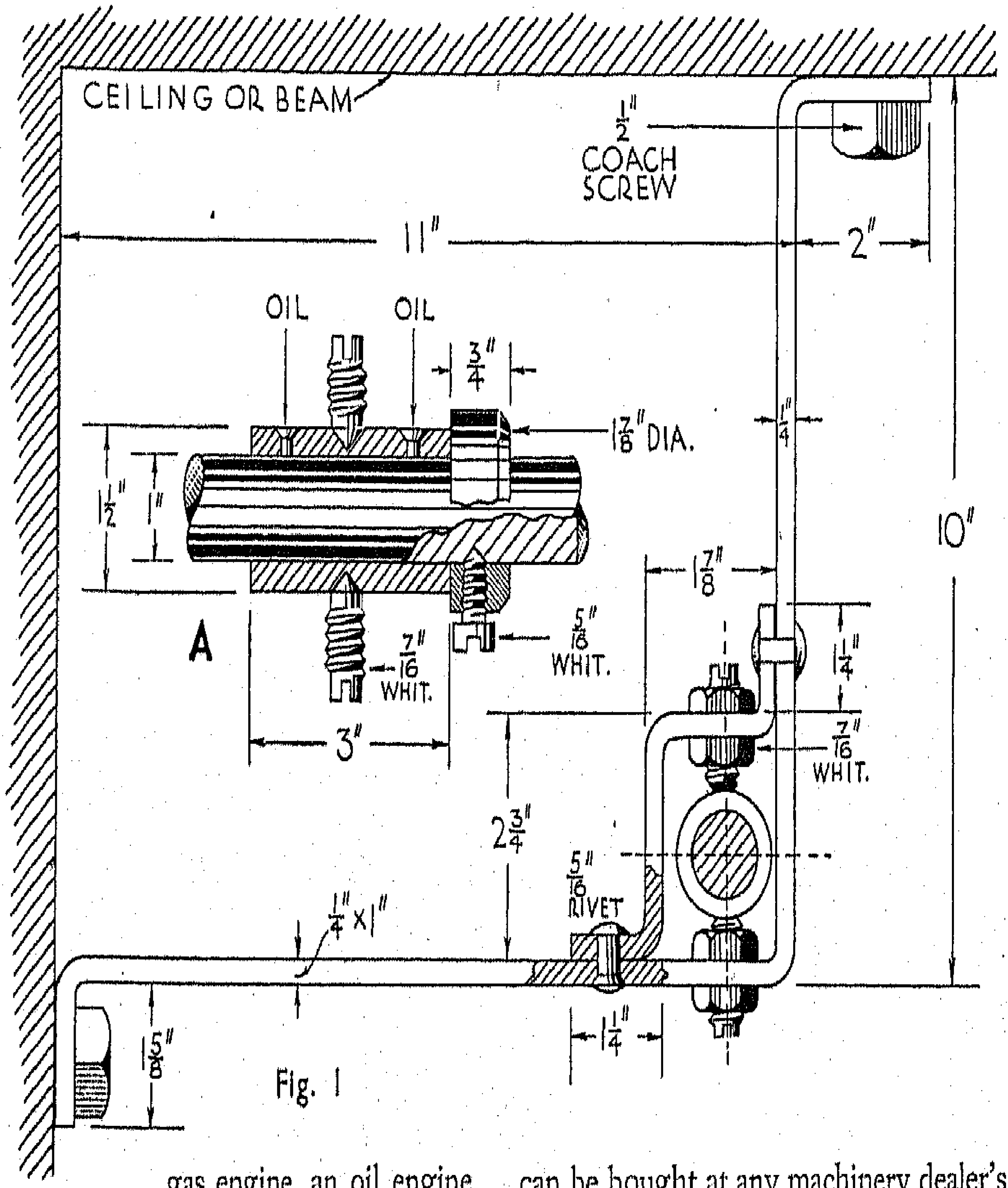


Fig. 1

For the amateur's workshop nothing very elaborate is required, but it should be strong and easily constructed and applicable to varying conditions as to walls, joists, ceilings, etc.

In the accompanying drawings are given the design and construction of three different types of hangers and brackets which can be developed to suit any amateur's workshop, no matter what type of building it is.

The shafting is 1 in. in diameter and can be bought at any machinery dealer's. Two kinds are standard stock, the bright-drawn steel and the turned steel. The former, for the 1-in.-diameter size, costs about eightpence a foot and the latter about sixpence a foot more. In the drawings 1-in.-diameter shafting is shown throughout, and readers can decide for themselves whether to use bright-drawn or turned. The latter is worth the extra sixpence since its accuracy makes for easy fitting and easy running.

In all the three kinds of brackets and hangers shown in the drawings the same arrangement of bearing is used. It is a plain casting of brass or gunmetal, 3 in. long, with a hole 1 in. (just full) to take the shaft, and 1½ in. external diameter. It is shown in section, carrying the shaft, at A, in Fig. 1. Two oil-holes, with flared upper mouths are drilled to allow of easy and effective lubrication, or they can be tapped to take oil bottles or screw-down greasers.

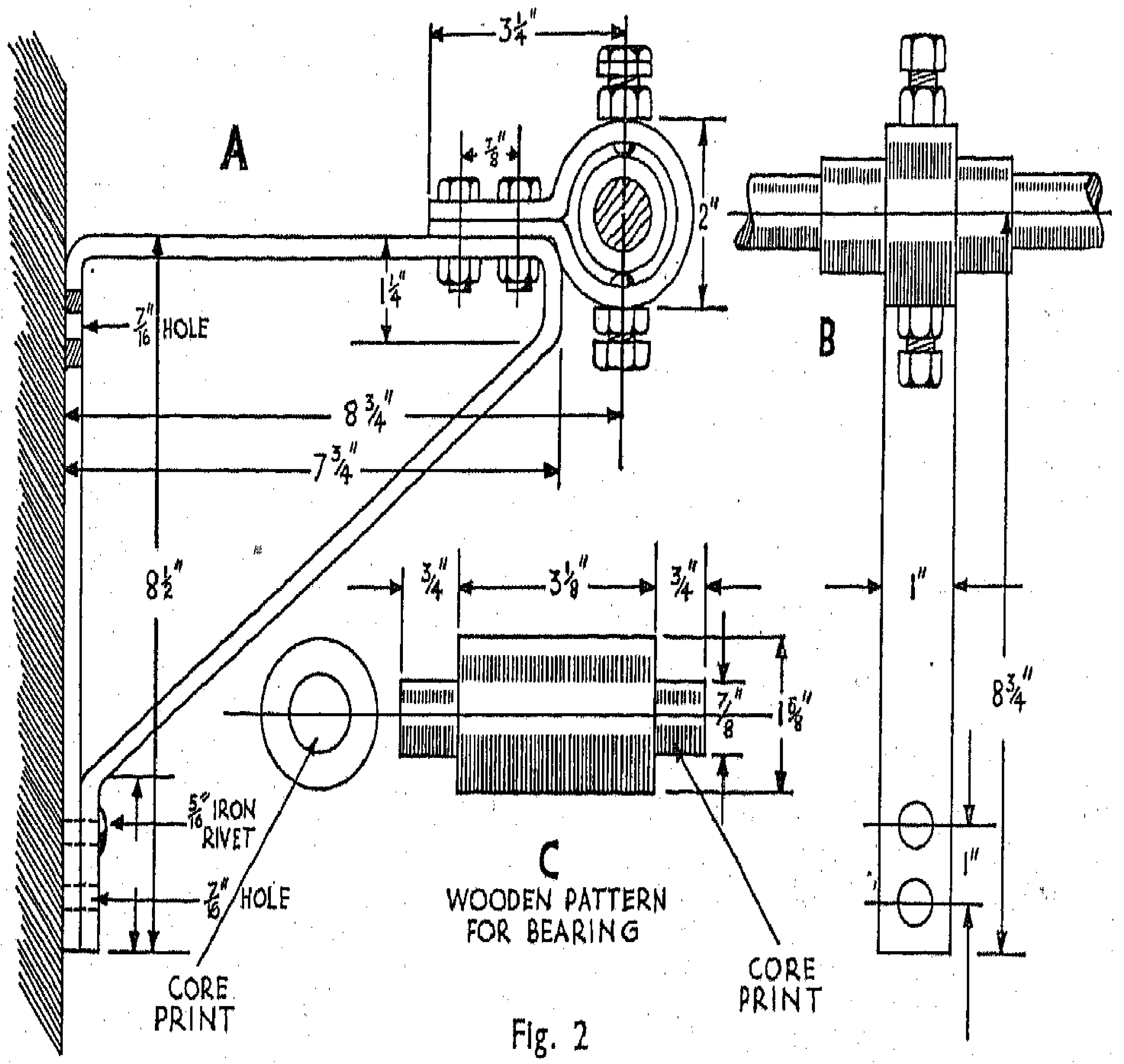


Fig. 2

A Pattern should be turned in hardwood to the dimensions shown at C, Fig. 2. These dimensions allow for machining, although there is no real necessity for doing any machining other than boring the hole; but it will look better turned on the outside and faced up at the ends. The core-prints at the end will provide a seating for a core which will leave the hole ⅞ in., so that only a small amount of metal will have to be taken off when boring.

The foundry will make the core (which is a simple sand cylinder) without a core box.

While making the pattern for the bearings, the reader may like to make also the pattern for the hub of the tinned-plate pulley shown at C in Fig. 4, and to be referred to later.

The Bearing (A, Fig. 1) should be mounted in a three-jaw chuck, with a slight space left at the inner end so that the boring tool can be pulled in at the end of the bore to take off the sharp edge. Cut 4 in. off the shafting and remove the burr at the edge with a file, and use this as a plug-gauge when taking the final cut up the bore. It must be ascertained beforehand that the lathe is cutting parallel in the chuck (not between centres). To do this, chuck a piece of

½-in. mild steel rod in the chuck well back and projecting 2 in. Then take a fine cut along, using the top-slide of the compound rest, and calliper each end with a micrometer and see if both are exactly alike. If they are, the hole in the bearing casting will be parallel. Do not alter the top-slide till all bearings and all wheel-hubs have been bored out, and do not use the self-acting feed, which may not be parallel for boring, although parallel for centre-work. It is also better to use the top-slide because a finer finishing cut can be made with it than the self-feed.

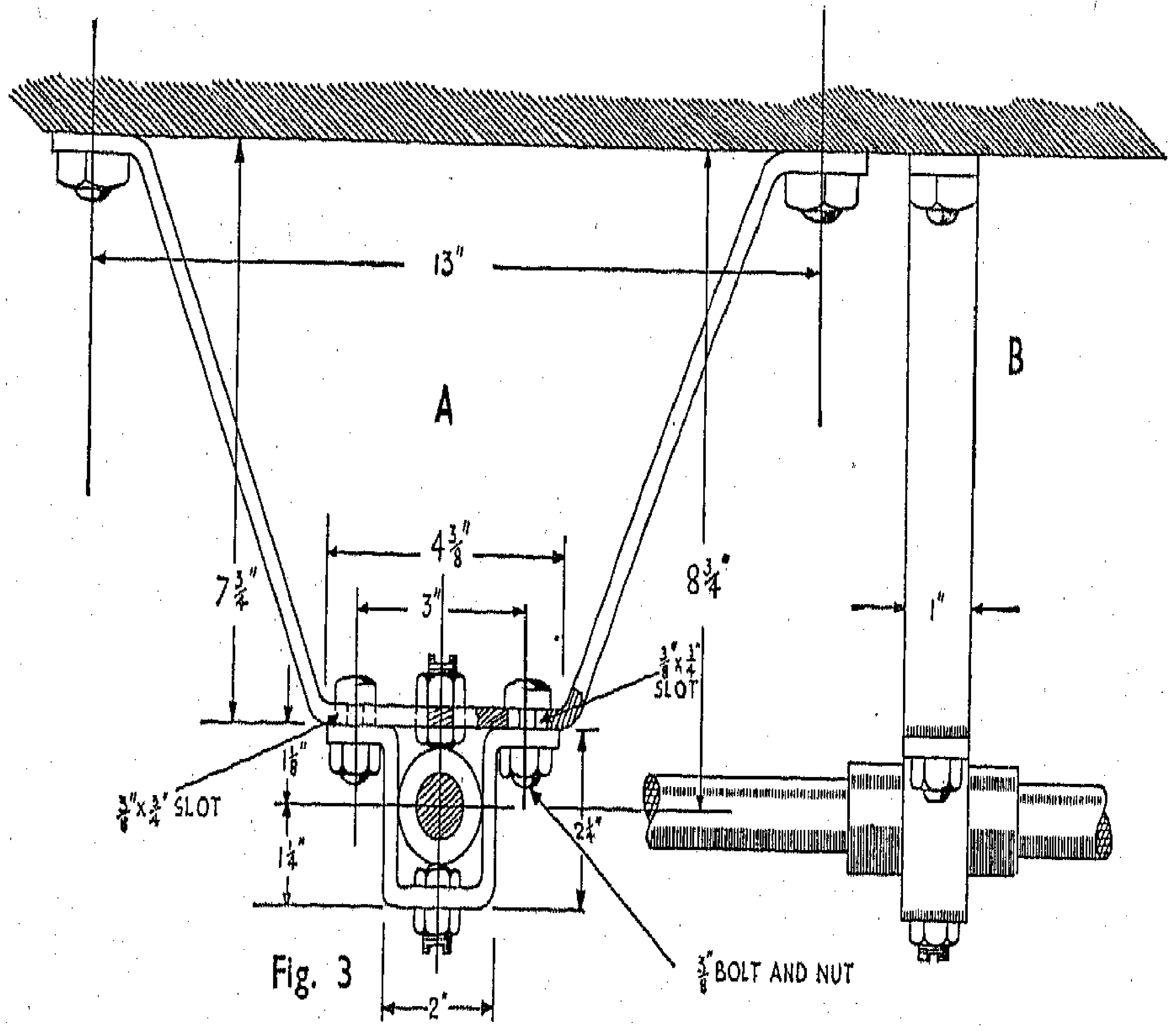


Fig. 3

The piece of shafting used as a gauge should push into the hole easily without any shake when lubricated. Then face off the end and remove the bearing from the chuck. Drill the two holes for oil and countersink them or tap them for lubricators. Then stand the bearing upright on the surface-plate or lathe-bed and scribe a line round it at the centre. Plug the end with a piece of flat hardwood and find the end centre with a pair of dividers or "moph" callipers, and scribe a line across the end passing through the centre. Lay the bearing in a V-block and scribe, with the scribing block, a line along each side coinciding with the ends of the line across the ends. The points at which these lines cross the central circumscribed line around the bearing are exactly opposite points. Here drill a ⅛-in. hole to the depth of just under ¼ in. and open it out to an angle of 90°, using a rose countersink, or a slightly more acute angle if you have a suitable countersink. The outside may now be turned—just skimmed up, if desired. It is probably better to leave it in its rough state, that is, as it left the moulding sand. In any case it should only just be cleaned up with the tool, and to do this it should be driven lightly on to a 1-in. mandrel between lathe-centres.

Steel Collars are used for keeping the shaft in position. Two collars are necessary for one shaft, and they may be placed at either side of any one of the bearings. If a pulley-wheel hub happens—in the laying out of the shafting and the machine or machines it drives—to come with its hub close to a bearing, one collar at the other side of the bearing will be sufficient to locate the shaft.

The collars are of standard size and can be bought with the shafting, but should the reader prefer to make them he can follow the dimensions on A, Fig. 1, which shows all necessary details. The collar is fixed on the shaft by a $\frac{5}{16}$-in. Whitworth screw, which should, of course, be case-hardened. Its end is pointed at a right angle and it screws through the collar into a slight countersunk depression made with a twist-drill in the shaft. This need not be more than $\frac{1}{8}$ in. to $\frac{3}{16}$ in. deep.

Figs. 1, 2 and 3 show clearly how the bearing is held by the pivot screws (shown at A in Fig. 1). They have Whitworth threads and may have hexagon heads or slotted heads, as desired.

The Hanger shown in Fig 1 is the simplest. Like the other arrangements (illustrated in Figs. 2 and 3), it is made of bar iron 1 in. wide and $\frac{1}{4}$ in. thick. To make the hanger, bend the iron at right angles 2 in. from the end (top right corner), then at right angles the opposite way at 10 in., and then at right angles again at 11 in. We then have the hanging bracket shown, which is screwed to the beam or ceiling at one end and to the wall at the other end.

The bearing is held in a rectangular loop formed by a piece of the same stock as the bracket, bent $1\frac{1}{4}$ in. up, $1\frac{7}{8}$ in. along, $2\frac{1}{4}$ in. down, and $1\frac{1}{4}$ in. along, and riveted into the corner of the bracket as shown—with $\frac{5}{16}$-in. mild steel rivets—one each end.

Drill holes in this rectangle, on a line which halves it vertically. These are tapping-size holes for $\frac{7}{16}$-in. Whitworth screws, so they must be $\frac{11}{32}$ in. diameter. The hole in the strap corner piece should be drilled before it is riveted in. Tap the holes with a $\frac{7}{16}$-in. Whitworth tap.

Prepare twice as many of the $\frac{7}{16}$-in. screws (pointed to fit the holes in the bearing and case-hardened) as you are going to make bearings. Case-harden them with "Kasenit" and fit them with nice, firm-fitting hexagon nuts and lock-nuts. The way the bearing is held in the brackets and hangers is quite plainly seen in all the drawings. The screws are screwed up to align the shaft when in position. When correct for height of bearing they are tightened up and locked with the lock-nuts. This will be dealt with later, when we come to fitting-up and aligning in position in the workshop.

With this hanger it will be necessary to assemble each bracket around the shaft with pulleys and bearings intervening, as required, before bolting up the hanger to the wall and ceiling or roof beams.

The hanger is attached by $\frac{1}{2}$-in.-diameter coach screws if a good depth of solid wood is available—say, at least 3 in. If not, ordinary bolts and nuts can be used. The holes are drilled at a suitable position at the ends. In some positions it might happen that one or both ends could be left straight and be bolted up to the sides of beams or along the top of walls.

The iron will have to be heated to a good red heat, and chalked beforehand where the bend comes. Then it is bent in the vice with a hammer to square up the corner. Do not "pull" the metal more than you can help or it will reduce its thickness and make it weak, and do not have the square corner bends too sharp. The amount shown in the drawings will give a strong construction.

In Fig. 2 at A and B is shown the ordinary type of wall bracket made out of quarter-by-inch stock. Here the bracket consists of one piece bent to a triangle and riveted at the bottom left

corner with a $\frac{5}{16}$-in. iron rivet, and further held by the $\frac{7}{16}$-in. bolts or screws which secure it to the wall, the bottom one of which goes through both thicknesses of the metal.

The bearing is held in a separate circular-shaped lug, formed out of similar stock as the bracket, and turned round a mandrel while hot, to 2 in. outside diameter. It is bent, while hot, round the $1\frac{1}{2}$-in. bar, and the ends closed up on each other in the vice and then cut off at $3\frac{1}{4}$ in. from the centre of the loop.

The loop holds the bearing, and has the $\frac{7}{16}$-in. Whitworth holes drilled through it and tapped to take the bearing screws—a feature common to all the arrangements. The loop is attached at the top of the bracket by $\frac{3}{8}$-in. Whitworth bolts and nuts in $\frac{3}{8}$-in. holes spaced $\frac{7}{8}$ in., centre to centre, apart. These holes are filed to form slots $\frac{3}{4}$ in. long, to enable an adjustment to be made along the bracket of $\frac{3}{8}$ in. With the vertical adjustment by the pointed screws which hold the bearing, and the fact that the bearing can swivel around the vertical axis of the pointed screws, it will be seen that the bearing is adjustable in three directions for alignment.

A front view is shown at B, and the dimensions of the bracket are clearly seen on both drawings. The bracket itself stands $7\frac{3}{4}$ in. from the wall, but the bearing loop takes the centre of the shaft out to $8\frac{3}{4}$ in. from the face of the wall.

In this drawing at C is shown the pattern, turned from hardwood, for making the brassfounder's mould for the bearing. It can be turned, with its two core-prints, out of one piece of wood. It is essential not to exceed the $\frac{7}{8}$ in. for the core or a casting may be obtained which will not bore out so as to give a surface in the inch-diameter hole.

Fig. 3 shows a more conventional hanger suspended from the roof, ceiling or beam; or used upside-down as a pedestal in those cases where it is convenient to have the shafting on the floor for machines driven below the table, such as fretsaws, circular saws, etc.

In this case the bearing is between the bottom horizontal member of the bracket and a dropped U-shaped frame bolted up to it. Both are of inch-by-quarter iron. The U-piece is fastened to the bottom of the hanger by two bolts in slots, which allow of adjustment sideways. The top pivot screw passes through a slot in the frame and is held in position by a nut and lock-nut. This can be adjusted to come vertically over the bottom pivot screw after the loop has been adjusted correctly.

Pulleys can be bought or made. Very light pulleys can be made of ordinary sheet tinplate of fairly heavy gauge.

Fig. 4 shows the construction of a 10-in. pulley with a 2-in. belt face. The same construction is, of course, used for larger or smaller and wider or narrower pulleys.

The Hub is a brass casting, cast from a hardwood pattern made to the dimensions shown at C, to which sufficient allowance has been added for machining. The casting is bored out to 1 in. diameter to fit snugly on the shaft, and has one shoulder a little longer than the other to take the grub-screw which fixes the pulley to the shaft.

The Sides of the Pulley are cut from fairly thick gauge tinplate to $10\frac{1}{2}$ in. diameter. There are two of these, the edges of which are knocked down to leave a ridge or lip, $\frac{1}{2}$ in. wide, square with the flat sheet. This can be done on the edge of a piece of 3- or 4-in.-diameter round stock, held in the vice, if the circle is first carefully scribed. The sheet should be held so that it lies on the top of the cylindrical block and the edge gradually hammered down all round to the scribed mark which indicates the outside edge of the corner. The disc is then cut across to the centre to form a V or gusset, as shown at E, and the edges of the V-shaped slot overlapped till the dishing is to the depth of ½ in., plus 7/16 in., as shown on the sectional drawing at D, the hole 1½ in. diameter having previously been cut in the disc.

The disc is held temporarily in the dished position by means of a thin pin inserted into a hole drilled in the overlapping portions of the gusset. A permanent joint is then made by efficiently soldering the seam. The soldering bit should be applied to the back and front of the gusset, allowing sufficient time to enable the solder to run well between.

The two discs are then fitted back to back on the hub, which has previously been tinned with solder, and they are soldered to the inclined double shoulder on the hub, the position of the two discs being shown at A—a sectional view. A couple of thin brass taper pins driven into holes made in each side will hold the discs to the shoulder on the hub during the soldering process and their outer back edges should be touching.

The work should now be tested for truth. To do this, mount the hub on a piece of shaft on which it can rotate easily, without shake. Grip the shaft in the vice and spin the double disc to see that it does not wobble sideways at the edge. If it does, correct it by bending till it runs true.

The rim is now to be attached. Take a piece of moderate-gauge tinplate and cut a strip 2¼ in. wide and 32 in. long. Bend this round the flattened peripheries of the discs. It will overlap by about ½ in. Tack it with solder at the edge where it overlaps and cut the strip across at the joint of the overlap, using a pair of tinman's snips for the purpose. Bend a piece of tinplate 1 in. wide and solder it underneath both ends of the strip when they are butted up close together, and cut the piece off ⅛ in. inside each end. The strip will be 1⅞ in. long.

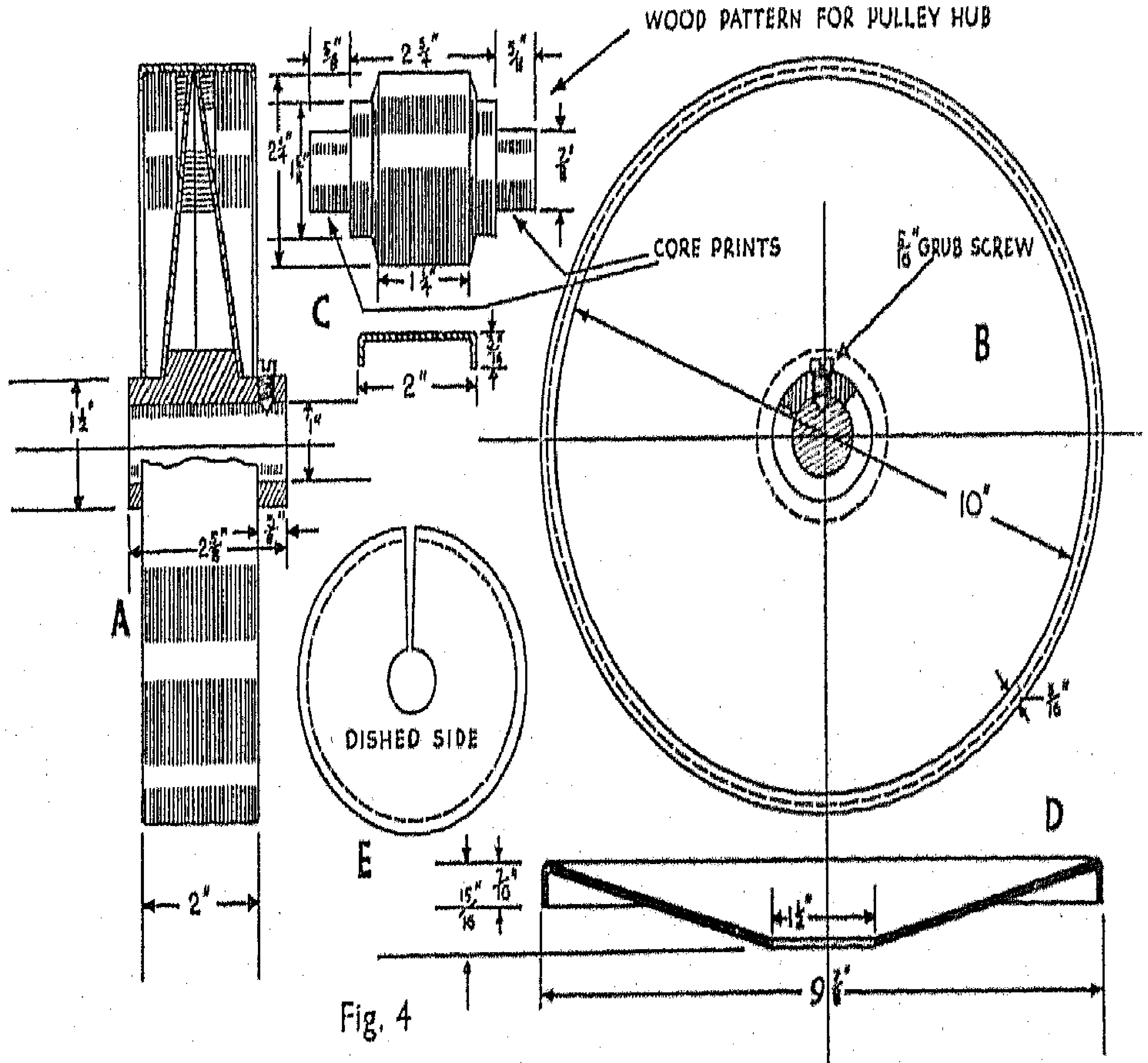


Fig. 4

Thus a hoop is formed with a joint flush on the outside and of a diameter to fit on the double disc.

Take the piece of round stock used for flanging the discs and bend both edges of the hoop down at right angles for a distance of ⅛ in. each side. This forms a stiffening edge smaller in inside diameter than the diameter of the flanged edges of the discs, but the hoop can be sprung over the disc and then centred on the flange face of the discs by using the piece of bar as a bearing, and spinning the pulley and adjusting the rim, or face, sideways on the double discs, as required. When true, the flanged periphery of the discs is soldered to the inside of the ring or hoop, which now forms the belt face.

A grub-screw driven into a threaded hole in the boss and into a corresponding depression in the shaft keeps it in position.

A Laminated Wooden Pulley may be used, as an alternative to the built-up sheet-metal one, and some amateurs may find it more convenient to make. One is shown at Fig. 5. Four discs of ¾-in. yellow deal are cut 10¼ in. in diameter and a central hole just under 1 5/16 in. is bored in each with a centre-bit. They are then glued together and when quite dry are threaded on a 1-in. gas nipple 3 in. long, which has a standard flange screwed to its end and sweated with solder on the threads to prevent it turning. This is seen clearly at the right-hand end in the sectional view. Another standard flange is then screwed as tightly as possible at the other end of the nipple, and the four ¾-in. laminations are further secured together by means of sixteen wood-screws driven in the flat faces of the pulley—eight in one side and eight in the other, in positions indicated by the full and dotted lines respectively, in the side view of the pulley.

The left-hand flange is screwed up tight by holding it in the vice, and a hole is drilled and tapped half in the

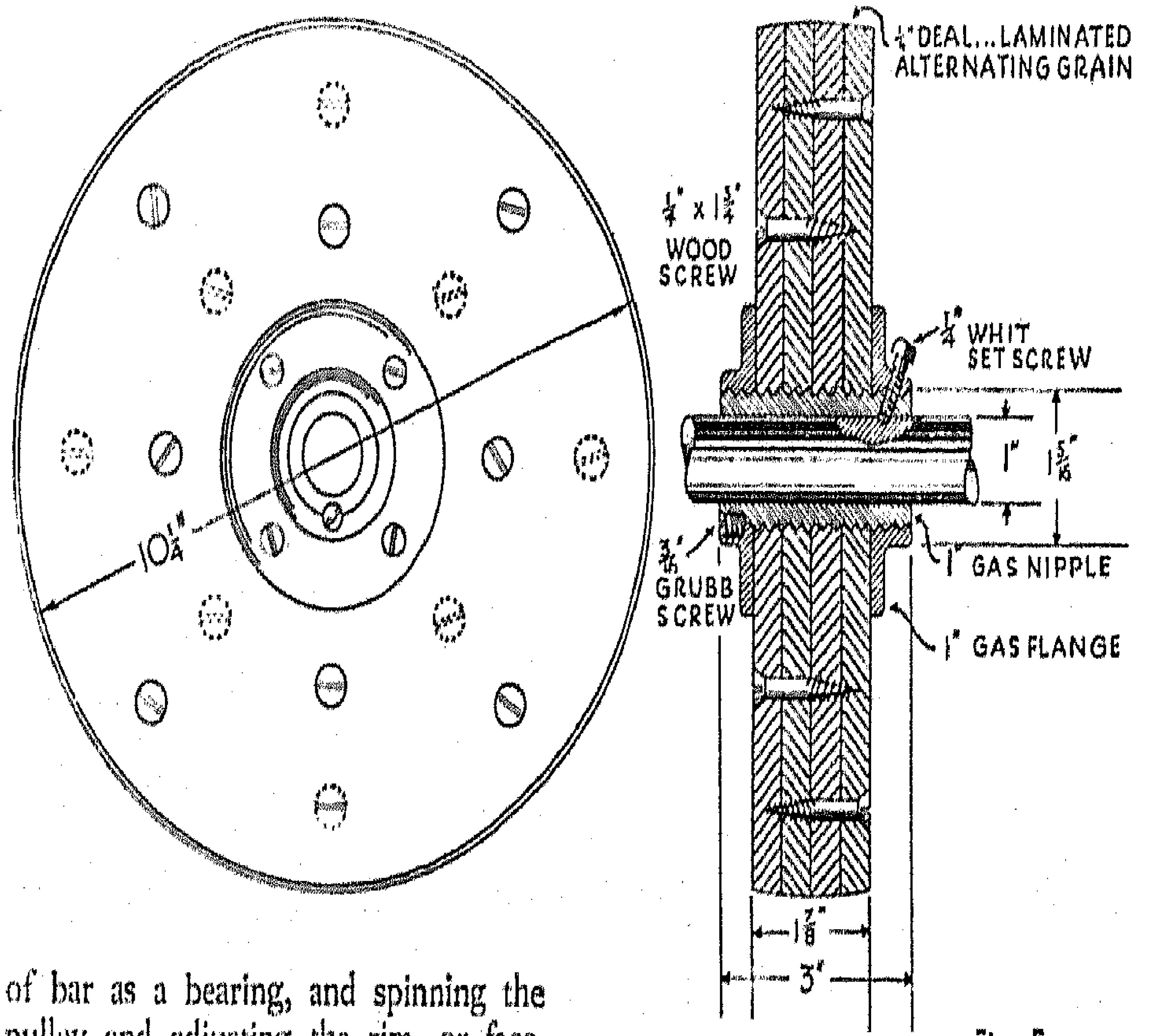
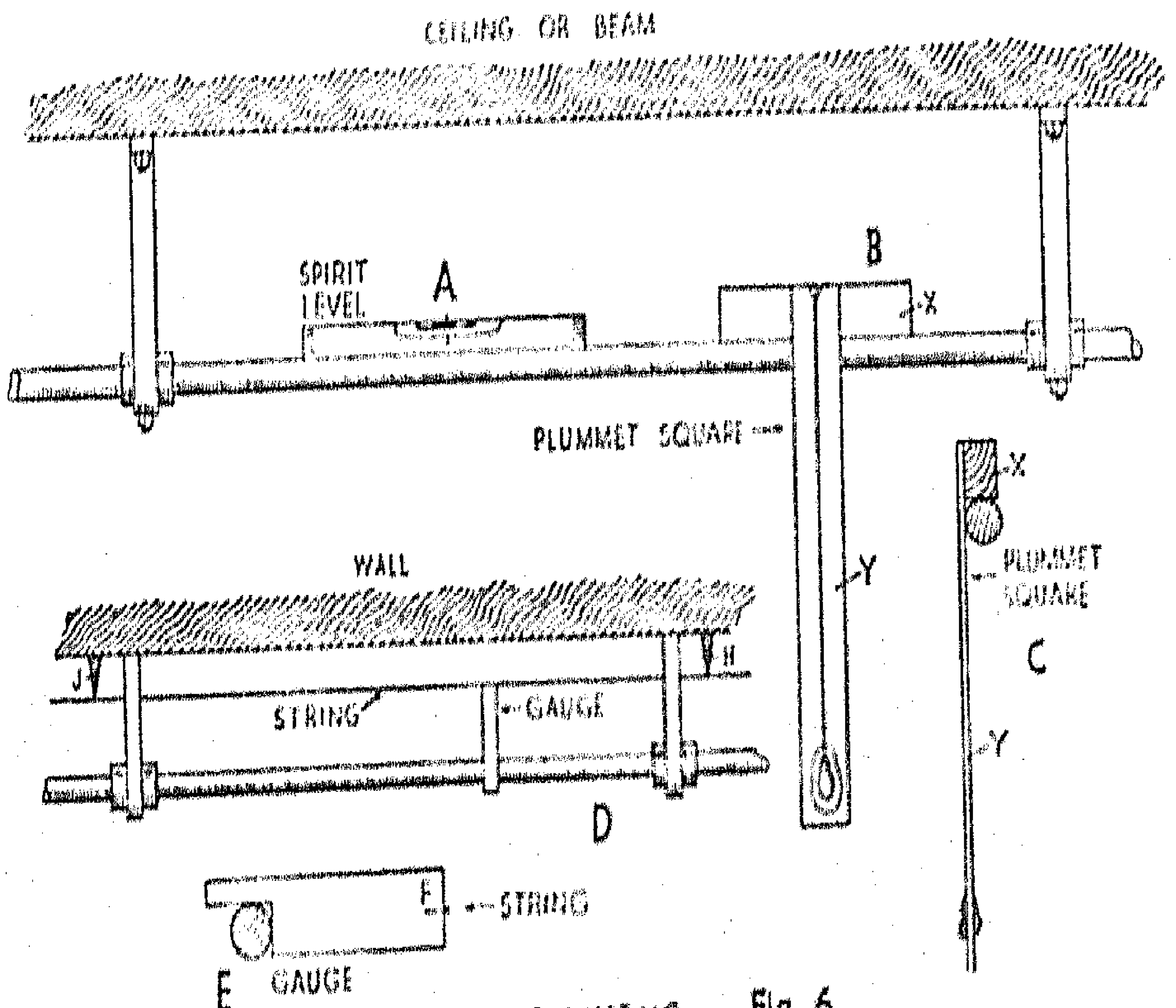


Fig 5

flange and half in the nipple to take a $\frac{3}{16}$-in. Whitworth grub-screw.

The screw-hole for the fixing-screw in the right-hand flange is drilled at an angle, as shown, and passes through the boss of the flange and through the nipple and into a depression in the shaft. The rough interior of the nipple is cleaned out to 1 in. (to fit the shaft snugly), either in the lathe or with a reamer. The gap is removed from the lathe-bed, the pulley driven on a shaft between lathe centres and the belt-face turned slightly convex. The convexity is slightly exaggerated in the drawing. It should be to a radius of about 12 in.



LINING UP SHAFTING Fig. 6

It must be understood that the idea of four laminations is to get the grain of the wood lying in four different (and equidistant angular) directions. This prevents splitting and offers an end grain of the wood to the belt at any part of its circumference, thus ensuring a non-slip "bite."

Both the tinplate and the wooden pulleys can be built to any desirable width and any diameter by following the instructions given.

In erecting the shafting, one end hanger or bracket should be fixed in position, at a given distance from wall and roof and at right angles to it. Then the other end bracket should be placed temporarily in position. The bearings should be fitted along the shaft and located by the pointed set-screws in the hangers or brackets. A long spirit-level on a straight-edge should be laid along the shaft as at A in Fig. 6, and the bearings adjusted, up or down, till the bubble stands central.

In place of a spirit-level the device shown at B and C may be used. It can be rigged up in the workshop roughly but accurately. It is a piece of wood of square section X, about 2 ft. long, with a wooden blade Y, about 4 ft. long, and is shown in the side view at C. The blade has a marked plummer-line and a plumb-bob and string, as shown in the front view at B. It is hung on the shaft as indicated, and the plumb-line shows whether the shaft is horizontal, i.e. square with the vertical—the blade Y being square with the stock X.

Having got the adjustment correct, so that the shaft is truly horizontal, the other brackets or hangers (if there are others required, owing to the length of the shaft) should be erected. They will have been strung on the shaft if of the type which has no detachable bearing-holder (as Fig. 1). They are adjusted for height to suit the position of the shaft, but left loose sideways. As the shaft is now resting in all the bearings and quite level (as tested again by the spirit-level or plummet), the necessary sideways adjustment, i.e. to or from the wall, can be made.

At D is a plan view of the wall (in section) and the shaft. Two nails or wooden plugs (H and J) are driven into or attached to the wall and a tight string is stretched between them. The string is at the same distance from the wall at each end and provides a straight line to work to.

Now make a gauge of a piece of hardwood as at E. It has a square recess at one end to locate it on the shaft and a scribed line (F) at the other, and its length between the inner edge of the recess and the square end is equal to the distance of the shaft from the string at H and J, less $\frac{1}{32}$ of an inch. You should just see daylight between the end of the gauge and the string when the mark (F) is placed opposite the string and the gauge held square with the shaft. If the shaft is bent sideways, by reason of an intervening hanger or bracket-bearing between the end ones being out of position, the daylight gap between the gauge-end and the string will be closed or widened. Whichever it is, make the lateral adjustment (by means described in the case of each method of supporting the bearing) till the shaft is parallel to the line all along. Then tighten all up.

Pulleys should be left loose on the shaft till the shaft is fitted and adjusted, as directed, for alignment. Each pulley can then be moved along to the correct position to line up with the pulley on the machine it has to drive, and a counter-sink made in the shaft to take the end of the fixing-screw of the pulley.

The diameter of the pulley which takes the drive from the engine or motor will depend on the engine or motor speed, the diameter of its driving pulley, and the speed at which it is desired that the shaft shall run. A suitable speed for the shaft for operating woodworking machinery would be too fast for metal-working machines, so a compromise must be adopted in cases where amateurs do woodwork as well as metalwork.

The ratio of the diameter of the driving pulley to the driven pulley is the ratio of the speed. The circumference can be neglected. If the engine or motor runs at 1,000 revs. a minute, has a 4-in. pulley and the driven shaft has a 12-in. pulley, the shaft will run at $\frac{1}{3}$ of 1,000 or 333·3 revs. per minute, which would be a very useful speed. The speed of the machine which the shaft drives will again be varied by the ratio of the pulley on the shaft and the pulley on the machine. If we gear down again from the shaft in the same proportion we get a speed of 111·1 revs. per minute at the machine-driving pulley. Therefore, with the 12-in. maximum pulley on the shafting and the 4-in. minimum pulley on the power, it is possible to get variations suitable for metalworking or woodworking.

As a rough approximation, it may be taken that woodworking machines require to be driven at three times the speed of metal-working machines.

WORKSHOP FOUNDATIONS

IN installing a workshop with tools that may be reckoned as plant and machinery, the first thing to consider is the arrangement. Light is an important factor. Artificial light may be placed to suit the tool, but to get the best results from daylight the tool must be fixed to get the light in the right direction. In the case of a lathe the light should come from over the user's right shoulder, so as to fall naturally on the face-plate or chuck and on the front edge of work which is being turned between centres. Better, more accurate and quicker work is produced, with less strain of hand and eye, if the light falls directly on the edge which is cutting off the metal. The ideal is overhead lighting—a glazed roof or skylight. The next best is a high window with the lathe at right angles to its left-hand side and with the head-stock at the end of the bed away from the window. These are the ideals to be arrived at, but they must, in most cases, be modified by particular circumstances, such as the positions of doors, fireplaces, etc. A little trouble and effort, in re-arranging things, will have a lasting effect on the ease of working and the quality of the work turned out.

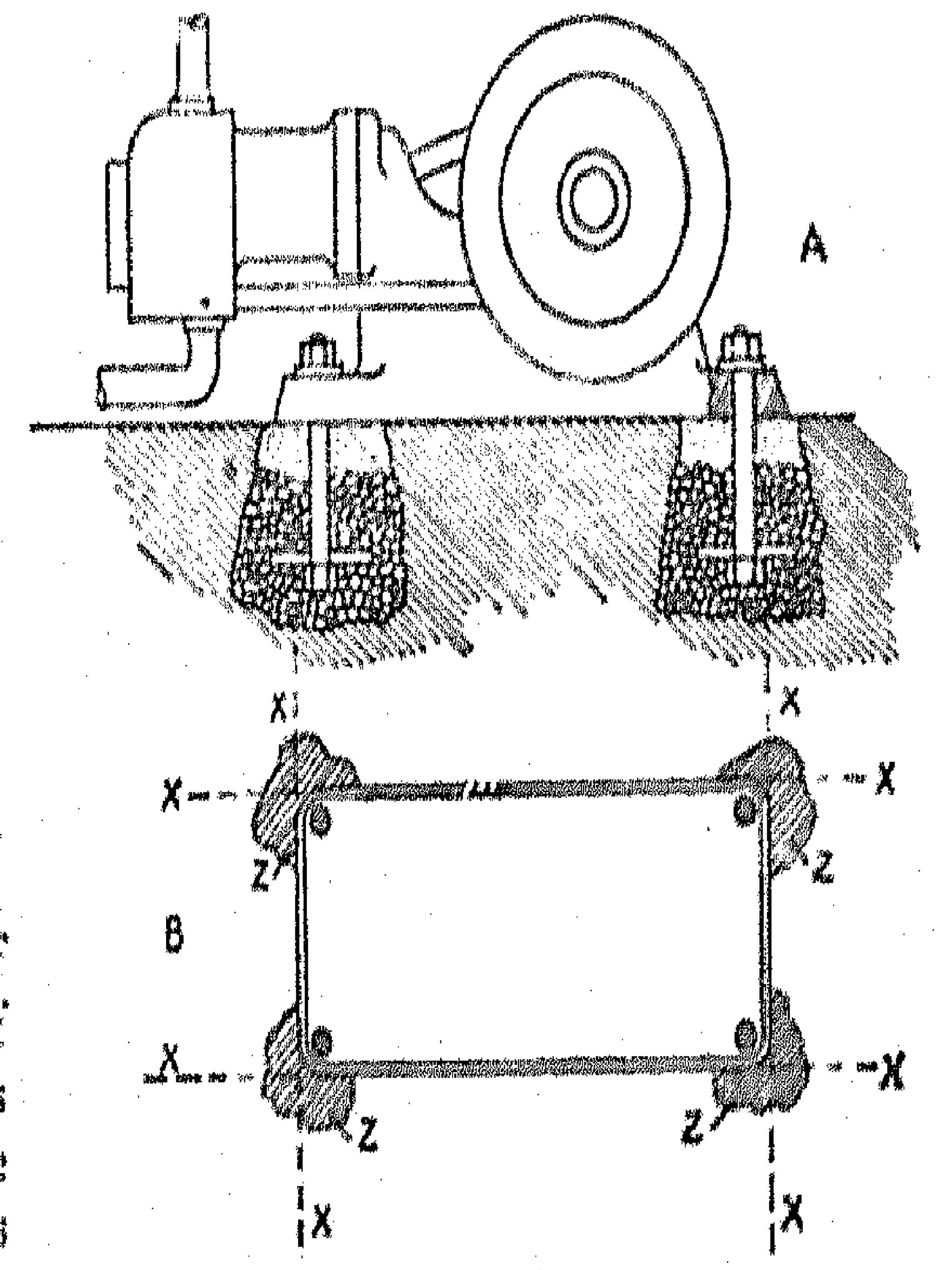


Fig. 1

In the article on SHAFTING AND PULLEYS we have dealt with the methods of installing them. Machines require equal care in their fixing and arrangement, and should be rigidly attached to floor or wall to prevent vibration. Especially is this so where they are power-driven.

For the purpose of showing suitable ways of forming fixings and foundations for tools, etc., examples have been made of a small gas engine, a shaper, a lathe and a drilling machine, showing different arrangements for different conditions. Obviously, the different fixings could apply to any of the machinesshown, or one method of fixing could apply to all of them, except the wall fixing of the drill.

In Fig. 1 is shown the most suitable arrangement for fixing machines which stand on a concrete, brick, stone or other solid floor.

Holes are dug in the floor for each holding-down bolt; and it is of importance that these holes should be deep, and wider at the bottom than at the top. To find the positions of the holes and the right location of the holding-down bolts is very simple if the following procedure is adopted.

When the shafting is in position, the machine (we will take the gas or oil engine in this case) is placed on the floor and lined up with the shafting and turned by hand to see that the belt does not run off or travel along the sides of the pulleys. The engine should be as far away from the shaft as the possibilities of the small workshop allow, and should drive at an angle nearer the horizontal than the vertical, if practicable. The best possible position having been decided upon and the engine (or other tool) standing in that position, lines are traced on the floor of the outline of the base of the machine. These lines are marked x–x, x–x, x–x, x–x in the drawing. The lines should extend well beyond the machine so that, if the outline becomes obliterated in the course of breaking into the concrete and digging the holes, their ends will still be visible and new lines can at any time be scribed, chalked or chiselled to locate the engine or tool when we come finally to lay it down.

Next, with a narrow chisel placed through the holding-down bolt-holes, and rotated as it is struck with the hammer, mark the positions for the bolts. This marking will soon become obliterated, but it will have served its purpose of ensuring that the hole will be made in a position necessitating the least amount of removal of earth or concrete.

Then move the tool, machine or engine away, and dig holes far enough towards the centre of the machine to reach the points where the bolts will come, reaching out sideways, or cross-ways, as at z, z, z, z, to enable the bolt-head and washer to be inserted from the underside up into its place after having moved the machine back into its working position. The holes should be about 9 in. or a foot deep for a small engine of about $\frac{1}{4}$ h.p., and deeper for a heavier engine or machine. The depth will also depend on the nature of the floor. If of good sound concrete the depth of the hole need not exceed 6–9 in. below the floor-level. On the other hand, should the foundation consist of nothing more than loose earth, with a thin concrete crust, the depth of the excavation should be a foot or more and it should extend well underneath on all sides. This will be a matter requiring judgment on the conditions obtaining in each individual case. The hole should be undercut, that is, it should be wide at the bottom and only wide enough at the top to facilitate digging the stuff out and getting the ballast (to be referred to later) and the bolt, nut and washer in.

The handiest tool for removing the debris is a garden trowel. The shape of the holes will be as shown in the sectional view at A in Fig. 1, and the mouths of the holes will be as shown in the plan view at B, where the engine has been replaced over the holes and, with the edges of the base lined up truly with the marks x–x, x–x, x–x, x–x, is now in position. Place a spirit-level across the top of the flywheel rim to see that the crankshaft is horizontal. If it is not, pack the engine bed up on the side necessary to make the adjustment. Pieces of broken slate are most useful for this purpose.

Now flood the floor round the engine with water and let the water soak thoroughly into the holes so as to have all in a moist condition. Prepare the bolts by substituting pieces of plate iron behind the heads instead of ordinary round washers. These plates should fit the bolts loosely and be about 4 or 5 in. square. Their shape is not important provided there is plenty of area. Any odd piece of $\frac{3}{16}$-in. or $\frac{1}{4}$-in. plate will do, with a hole drilled through of the same diameter as the hole in the engine or machine-tool bed.

Slip the plate, with the bolt through it, into the excavation and push the bolt up through the hole in the engine bed. Then, having greased its thread well, place a washer and a nut on to the thread and let it hang down vertically in the hole, allowing the end of the bolt to protrude about $\frac{1}{4}$ in. through the top of the nut when the nut is down on the washer and the washer is down on the bed of the engine.

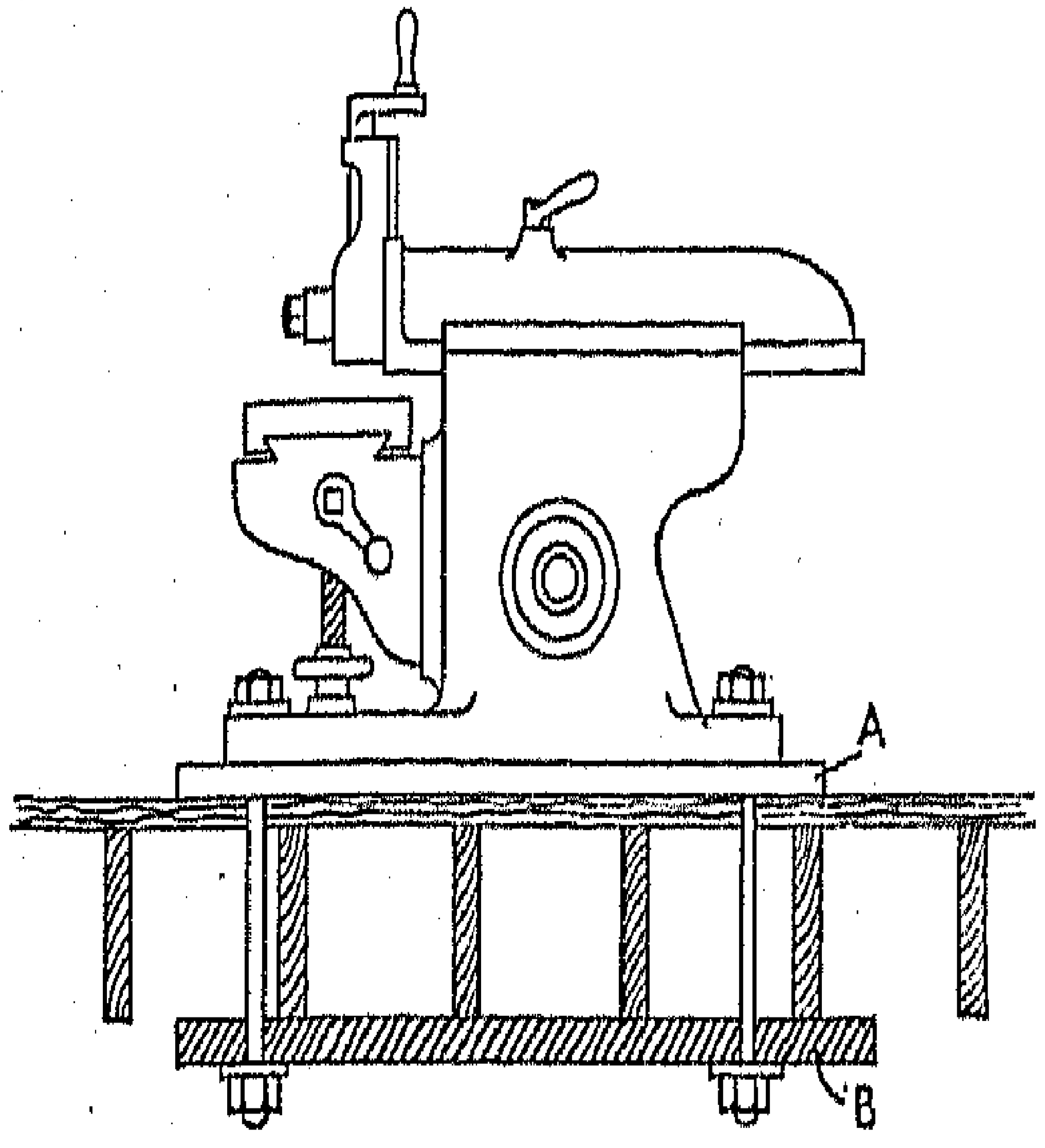


Fig. 2

Now fill the hole loosely with pieces of broken brick, cement or stone. These pieces should not be larger than $1\frac{1}{2}$ in. diameter and not smaller than $\frac{1}{2}$ in. They should be clean and wetted before putting into the hole, and should be pushed down below the plate and fill the hole to within $\frac{1}{4}$ in. of the top. When adjusted, the nuts should stand vertical and square (flat) on the bed of the machine.

Now mix some fresh Portland cement to the consistency of fresh cream, and add a little clean, fine sand (not sea sand, which would sweat) in the ratio of one of sand to three of cement. Mix enough to fill all four holes and pour it in quickly, stirring a little with a piece of rod while so doing, to ensure the cement penetrating around all the brick pieces, etc., and filling the whole of the orifice, to the level of the floor.

If the engine has to be raised, to bring its shaft horizontal, swill liquid cement in the space between the bed and the floor. Do this all round the corners and sides to ensure that, when set, the engine (or tool) rests everywhere on the cement. Then smooth off and leave for at least 48 hours to set, occasionally swilling water over it to assist in the hardening and toughening. Do not on any account touch the bolts or nuts till the job has stood for at least a week. The cement, when thoroughly hard, will hold the square head of the bolt, but, if an attempt is made to turn the nut before that, the bolt may turn and make a round recess for its head, making it difficult or impossible to tighten the machine down by the nut.

Where a workshop has a wooden floor, supported on joists, the arrangement shown in Figs. 2 and 3 should be used. The machine should stand on an iron plate A (Fig. 2) a little larger than the base of the machine. It could be about $\frac{3}{16}$ in. thick for a small machine.

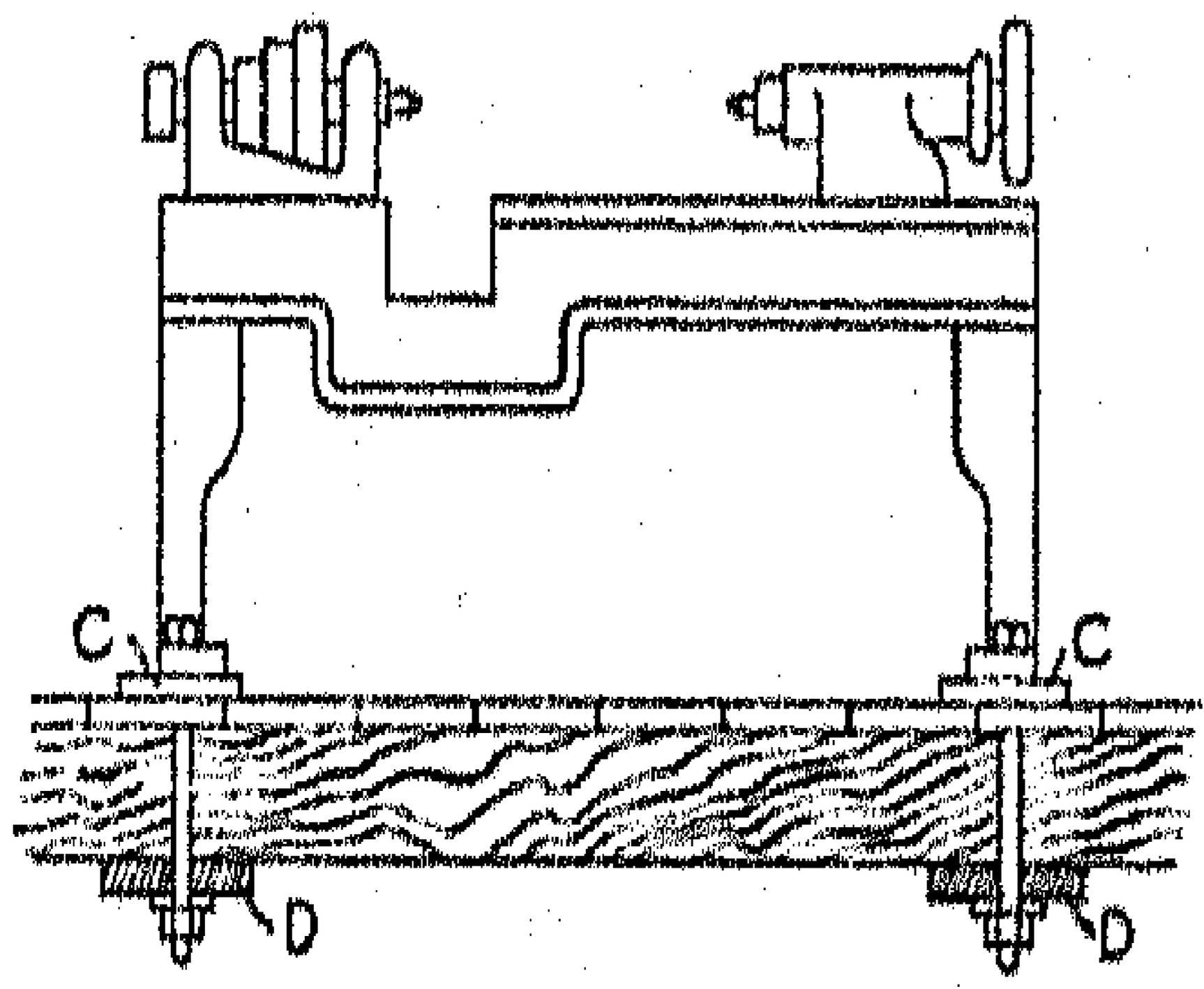


Fig. 3

And on this the tool should be laid in the right position so that the bolt-holes miss the joists. Each pair of the four bolts should go through an iron bar, B, underneath the joists. The bar should be of $\frac{1}{4}$-in. flat stuff, $2\frac{1}{2}$ in. wide and long enough to reach well past the outer edges of the joist. Long bolts (which may have the nuts below or above or at both ends as convenient) hold the machine firmly to the joists when all is tightened up.

When the joists run in the direction of the length of the machine, as at Fig. 3, which shows a lathe so disposed, hardwood battens, C, C, twice the width of the feet, may be used, and, underneath, $\frac{1}{4}$-in. iron bars 2 in. wide, marked D, should be employed to take the pull of the bolts and brace the lathe firmly to the joists. It is bad practice to bolt a machine direct to floor-boards as it tends to loosen boards and joists. The methods shown actually increase the strength and rigidity of the floor and are well worth while; they will be fully appreciated when it comes to running the machine in actual work.

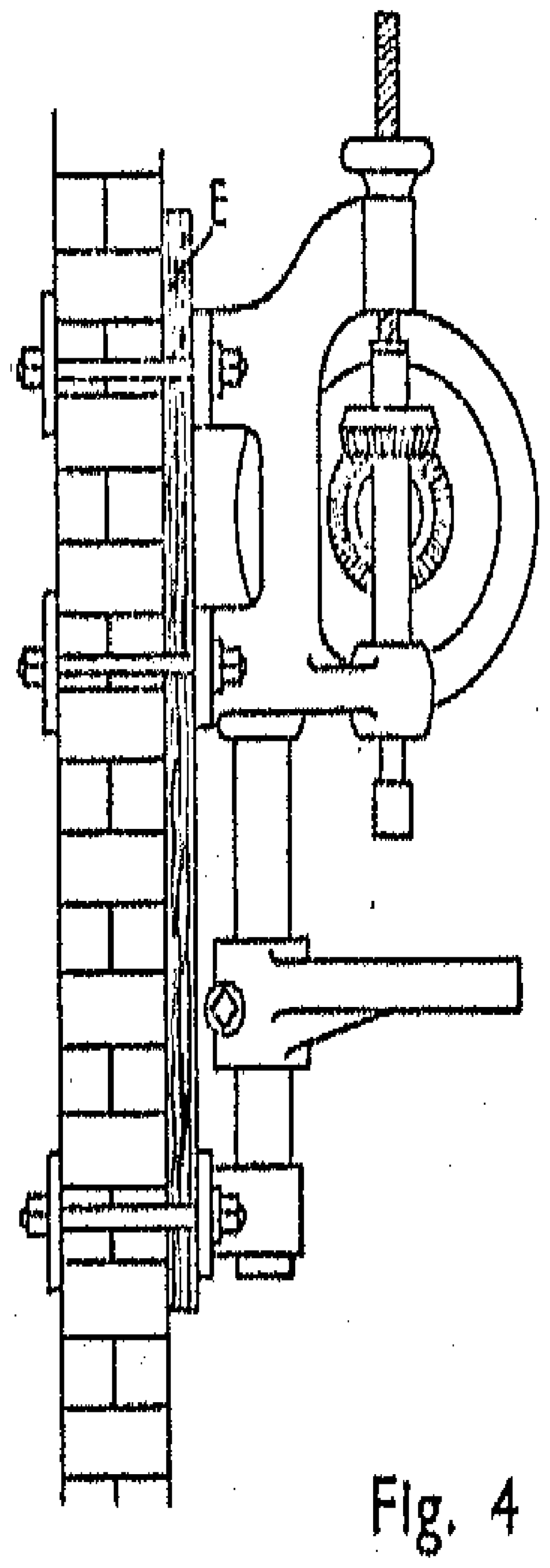


Fig. 4

Fig. 4 represents a post drill bolted to a 9-in. brick wall. Such a machine should not be placed against a lath-and-plaster partition. The wooden back-plate E should be of oak and at least $1\frac{1}{4}$ in. thick. Bolts $\frac{1}{2}$ in. diameter are used. They should go through the wall at points corresponding with the interstices between the bricks, if possible.

To fit up the machine, mark out the back-plate for the holes and drill them to take the $\frac{1}{2}$-in. bolts. Then lay the plate up against the wall, fixing it temporarily by means of one or two 3-in. wire nails, and mark on the wall the positions of the bolt-holes. Arrange them to come, if possible, at a vertical or horizontal brick-joint. Then drill the corresponding holes $\frac{3}{4}$ in. diameter through the brick, using a tool consisting of a piece of iron, gas or steam barrel with one end serrated by means of a three-square file. The tool is used by striking it on the head with a hammer and rotating it slowly with the hand. The particles of brick which enter the tube and sometimes choke it should be removed from time to time to prevent jamming and impeding cutting. This is best done by holding the tool vertically and tapping it with the hammer. The drilling machine and its back-plate are bolted up with 4-in. wide bars of iron plate at the back, under the nuts or heads as the case may be. A channel should be cut in the brickwork from a position above these back-plates to meet the hole, in the case of each bolt-hole. When all is bolted up fairly tight the back-plate of the drill should be tested with a plummet-line to see that it is vertical. Then pour liquid Portland cement into the channels at the backs of the iron plates to fill the space around the bolts. When dry, the bolts will be perfectly rigid and thus prevent the machine shifting. This extra rigidity of the bolts is particularly necessary when drilling a piece of work which can only rest on the floor. This is often very convenient, but if the bolts were not cemented into the wall as described, the pressure of drilling would force the drilling machine upwards, loosening things and straining the bolts. When the cement sets the nuts are tightened.

BELTS AND BELTING

There are many kinds of belting used for driving machines from a line-shaft, but for the small workshop there is nothing to equal the old-fashioned flat leather belt. It should be thin and, so, supple enough to enable it to hug the face of the pulley, for it is on the frictional resistance against the belt slipping on the pulley that the drive depends. If the belt is stiff it will not lap closely round the face and the area in close contact will be insufficient to transmit the drive without slipping.

The width of the pulley should be one-fourth greater than the width of the belt. In the description of workshop Shafting and Pulleys we have shown pulleys of 2 in. in width. On such pulleys $1\frac{1}{2}$-in. belting will run nicely without fear of overlapping the edges. If the belt overlaps the edge of the pulley the leather will be stretched along the flat and not at the edge, and there will be a tendency for the belt to become distorted, which may cause it to run in any direction and therefore be liable to slip off the pulleys or ride with its edge in the centre of a small pulley—for instance, that of an electric motor, which has a slight surface curvature.

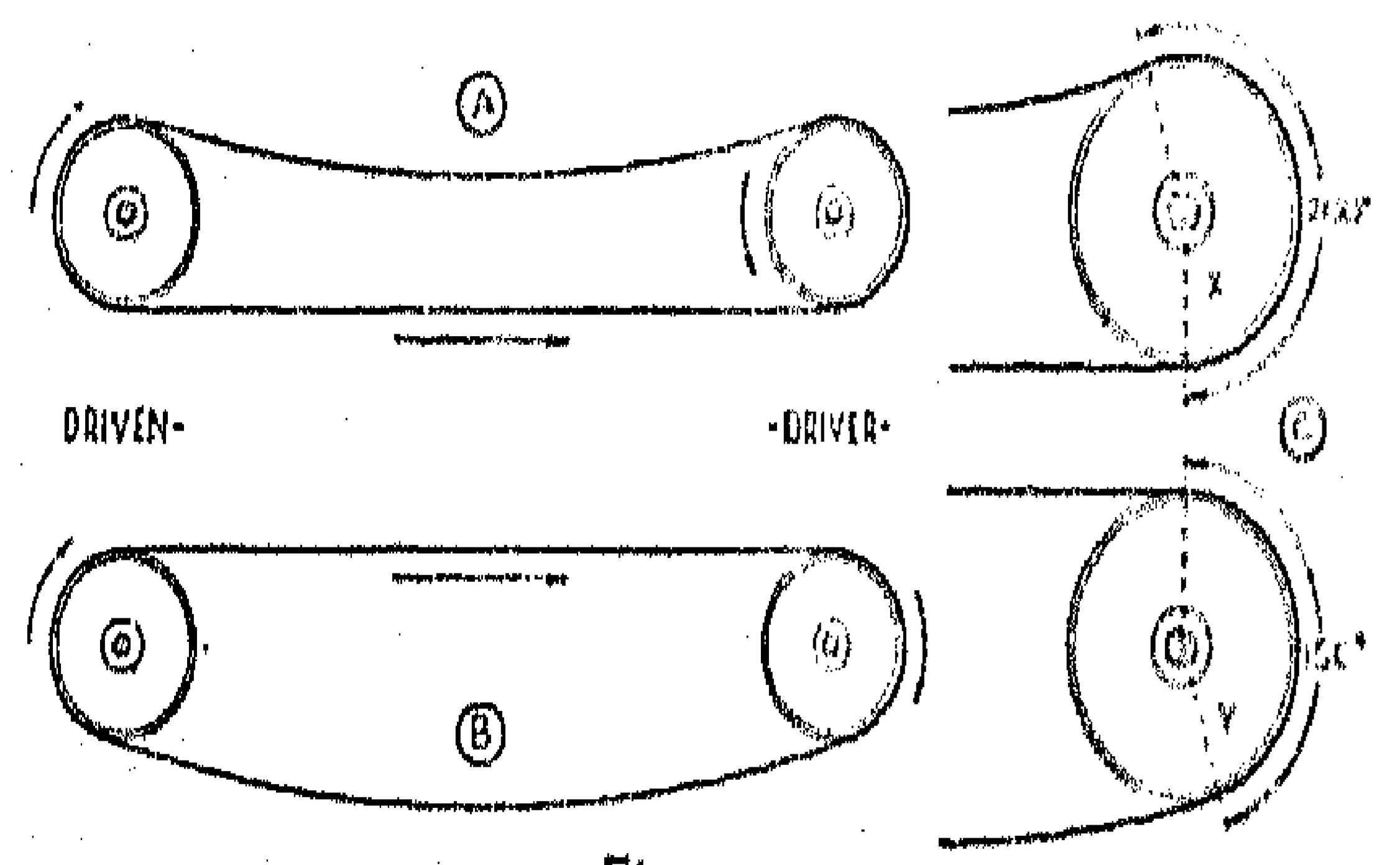


Fig. 1

In actual practice, certain pulleys should have a slight camber. It is general practice to have a rise of $\frac{1}{8}$ in. in 1 ft. of width, so that a pulley with a 12-in. face would be $\frac{1}{4}$ in. bigger in diameter at the centre than at the edges. A pulley with a slightly convex face has the effect of causing the belt automatically to centre itself, but the pulleys on machines, lathes, etc., and the pulley on an electric motor or small gas or oil engine may possibly be flat or have a very slightly convex face and if so it will be sufficient, presuming the pulleys are accurately in line, to ensure that the belts stay on. In the case of a sudden excessive strain the belt may leave the pulley, but this is not always a disadvantage because the sudden cessation of drive may conceivably avoid damage either to the tool being used or to the work on which it is being employed.

A wide belt running slack is preferable to a narrow belt running tight. There should be no need to run belts tightly. A tight belt absorbs a great deal of power which should be used in doing useful work. It also has the effect of wearing shafts and journals rapidly. This applies to both the bearings of shaftings and the bearings of machine spindles, such as lathe mandrels, saw spindles, etc. To obtain a good frictional contact between belt and pulley, the direction of the drive should be carefully considered. The whole efficiency and economy of the drive may depend on this simple problem.

A Vertical Drive is the worst of all drives for belts and should be avoided wherever possible. A horizontal drive is good if the slack side of the belt is uppermost so that the weight of the belt tends to wrap it farther around the pulleys.

A Horizontal Drive.—In Fig. 1, at A, is shown the correct arrangement.

The driving pulley pulls the driven pulley from the underside. This keeps the belt taut on the underside and its weight sags it down on the upper side so that it encircles more than half the circumference. The illustration at B shows the arrangement with the belt pulling on the upper side. The sag due to the under weight of the belt is pulling the belt away from the pulley, and the amount of surface of the face in contact with the belt is less than half the pulley circumference. Diagram C in Fig. 1 shows, at X, the arc of surface contact of a belt running as at A, and at Y the arc of contact of a belt running as at B. The difference is particularly noticeable as it represents the condition in both driving and driven pulleys. In one case the arc of contact is 200 degrees; in the other it is only 150 degrees.

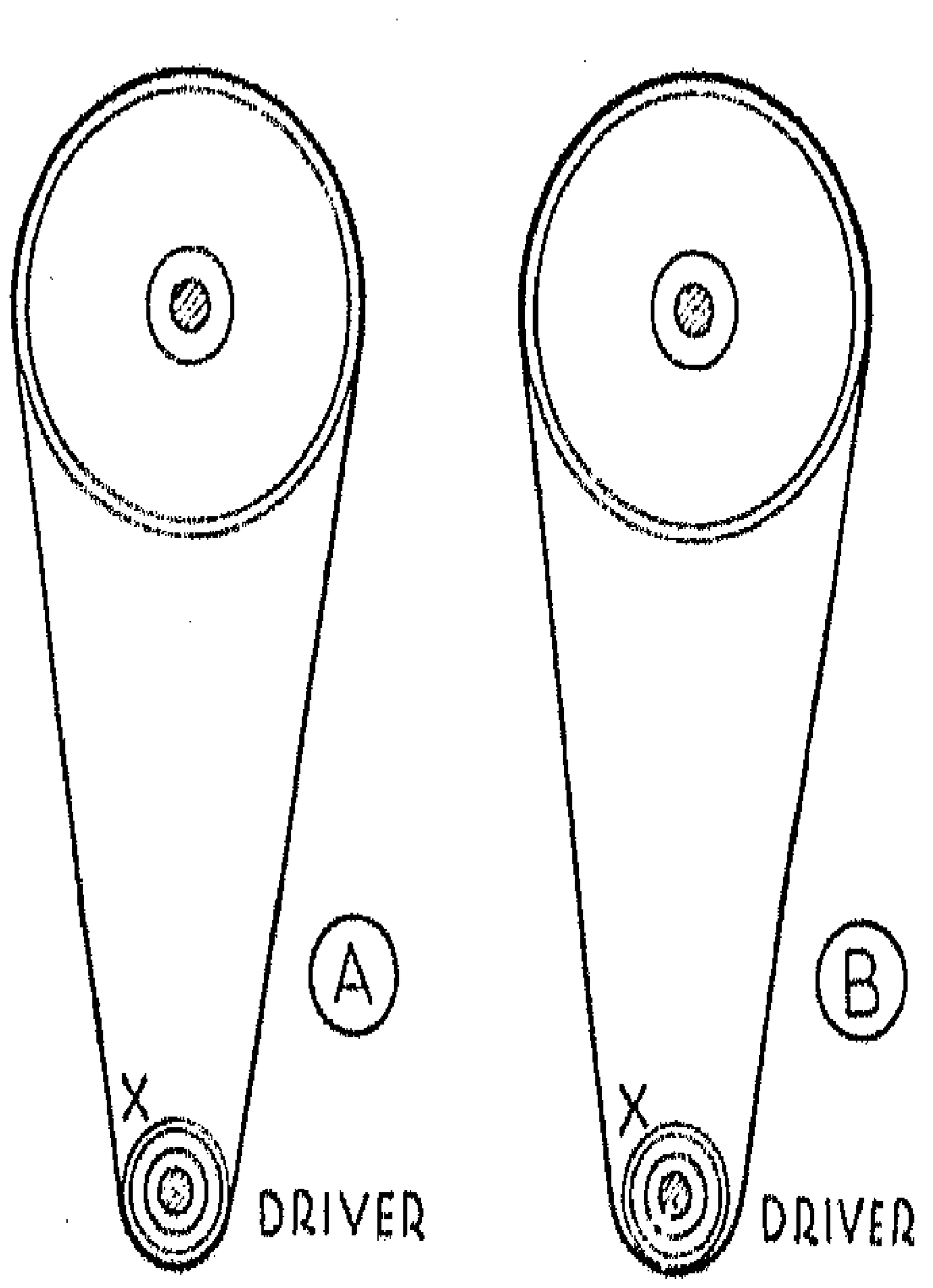


Fig. 2

Fig. 2 shows an inefficient vertical drive as from an electric motor to an overhead shaft. The whole weight of the belt is tending to keep it out of contact at both sides and bottom with the driving pulley X. A belt drive for an electric motor should be so arranged to have a good angle from the vertical. It should be at an angle of at least 45°, as shown in Fig. 3, and it should pull from the bottom as indicated by the arrow. As the armature of an electric motor is small (on account of the high speed necessary to obtain a given power) every advantage should be taken of the weight of the bight of the belt, Y, to get the maximum amount of sag to enable the belt to embrace as much of the circumference of the pulley as possible. It may even be found advisable to place a spring or weight-loaded jockey-pulley at the back of the driving pulley, as in Fig. 4, at X, to keep the belt in close contact with the driving pulley for a greater surface of its circumference. The jockey-pulley should have a slightly concave belt-surface to match the convex surface of the driving motor pulley.

In a small workshop, using very small power, this would hardly be necessary, the best procedure being to increase the width of the pulley-face and use a wide belt. If the belt is soft and flexible and kept well dressed with colon oil or belt dressing (which can be had from the motor-car supply houses), and is wide enough, it will transmit all the power required if the angle of the drive is 45° or less from the horizontal. In cases where short pulley drives are

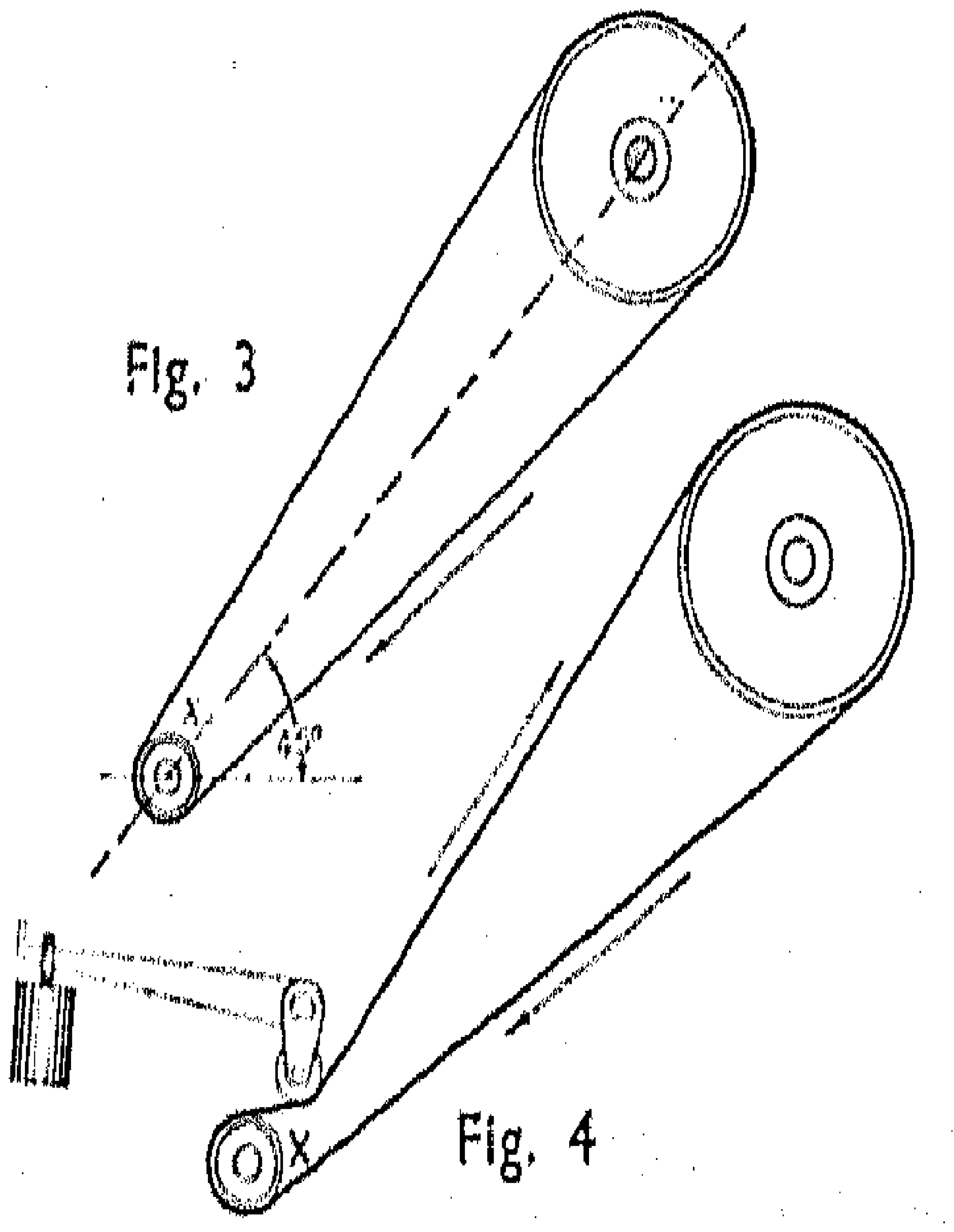


Fig. 3

Fig. 4

essential the best way is to arrange the drive as nearly horizontal as practicable by mounting the motor on brackets fixed to the wall opposite to the one supporting the shafting. This would drive the shaft by the top weight of the belting being in tension, as in Fig. 5.

In all belt drives efficiency and absence of slip without strain on the bearings can only be obtained by keeping the pulley centres as far away from each other as possible. No short drive can be efficient.

In dealing with belts in general remember that tensioning up absorbs a lot of power. A lathe can very quickly be made inaccurate if driven constantly with a tight belt. A slack belt sagging on to the pulleys and not away from them gives the best results, i.e. least slip and least power absorbed in the drive and least wear and tear on shafts and machine bearings.

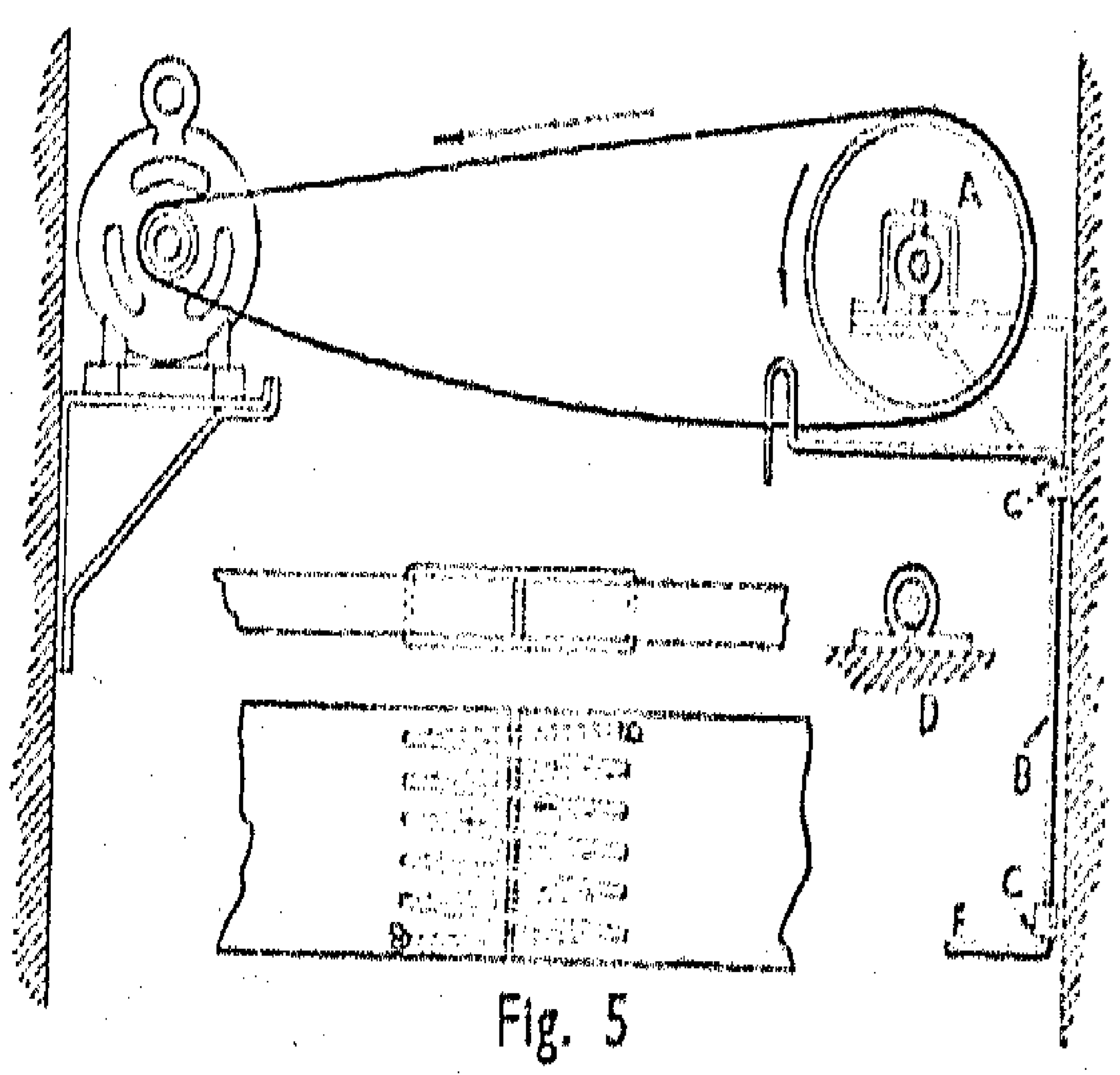


Fig. 5

In the case of a lathe driven from a main shaft, a countershaft is necessary so that a three-step cone pulley may be used to drive the lathe-mandrel at various speeds. In some cases, where the shaft is driven by a slow-speed prime mover—such as a gas or oil engine—the three-step pulley could be mounted on the shafting direct and changes made as wanted by hand, but this is not advised as it is not only very inconvenient but also dangerous, because it means throwing off the belt to stop the lathe.

For a small workshop the arrangement shown at Fig. 5 will provide means of getting over the difficulty. In this case the pulley on the motor armature is made 6½ in. long for a 3-in. belt, and two 3-in. wide pulleys are used at A. One is screwed to the shaft and the other free to revolve on it, so that its face rides close to the face of the fixed pulley.

A Simple "Striker" for shifting the belt from one pulley to the other is made of a piece of ½-in. iron rod B, placed vertically and kept in position on the wall by means of bent strip loops C (shown separately at D). The handle is bent horizontally at E, and at the top is a horizontal arm bent upwards, and down over the belt at the other side. By pulling lever E the belt is led from the fast to the loose pulley. If the lathe is fixed down to the floor and to the wall—as it will have to be—the lever E can be placed in such a position as to make the stopping and starting of the shaft easy and accessible, and the arrangement does away with the necessity for a fast and loose pulley countershaft, as the three-speed cone pulley is mounted on the shaft which carries pulleys A.

In the small shop it will probably never be necessary to run other machines while the lathe is being used: and so stopping and starting the whole shaft will be no particular disadvantage—none at all if the workshop-owner is the only workman.

For small belts which have to go over small pulleys and do not have to transmit much power the belt joint should be such as to easily bend round the small pulley and not to give a shock or blow in running. There are numerous kinds of belt fasteners on the market. They all give a little irregularity to the belt as it rides over the pulley. In a small machine and on small work such shocks are to be avoided. The raw-hide thong lace for making belt joints is the best. Thread the lace through the belt as shown in Fig. 5, and knot the ends. The ends of the belt are cut square so that their edges butt together. It should be laced up very tightly so that the two ends of the belt more than butt up close: any thickening is then hammered down with a flat hammer on a flat iron surface. The ends will then bed down flat and square to each other, and the raw-hide will be embedded in the leather. This makes an excellent joint for light work such as that under consideration, and if the belt stretches it is an easy matter to unlace it. In dealing with a stretched belt, cut off ½ in. or 1 in. and scarf the ends to match, then lace the belt with the raw-hide lacing again. Use a proper belt punch for making the holes for lacing; holes made with a knife or solid punch are unsuitable. Have a punch of just sufficient size to cut out holes of the same diameter as the lace. The knots at the end of the lacing should lie on the outer surface. Another method is to start the lacing in two adjacent end holes with the same amount of lace coming through each hole and then cross the laces as each pair of holes are threaded, finishing on the outside of the belt. Note that the outside is the smooth side, and the side next to the pulley the flesh side of the leather.

The driving side of a belt should be kept clammy, as this condition allows the belt to drive, when a little slack, without slip. Thin wide belts drive better than narrow thick ones, and a thick belt will not hold to a small pulley at the bottom of a vertical drive. A highly polished pulley usually indicates a slipping belt, which should be treated with one or other of the numerous belt compositions.

GAS ENGINE OVERHAUL

A GAS engine will become inefficient and expensive to run unless occasionally overhauled. It is not a long job nor an intricate one.

Take off the cap nuts of the big-end bearing. Draw back the end cap carefully, taking care not to pull it sideways or it will jam on the bolts. Then push the connecting-rod and piston back by turning the crank. Let the crank come round forward and down to six o'clock, and then the piston and rod can be removed. Clean the piston-head by chipping and scraping off the carbon or coke. Examine the rings. If much wear is apparent, new rings are indicated, which are best got from the makers. The rings should spring out to a good $\frac{3}{16}$ in. all round when the piston is clear of the cylinder. If the rings have good pressure outwards, but have

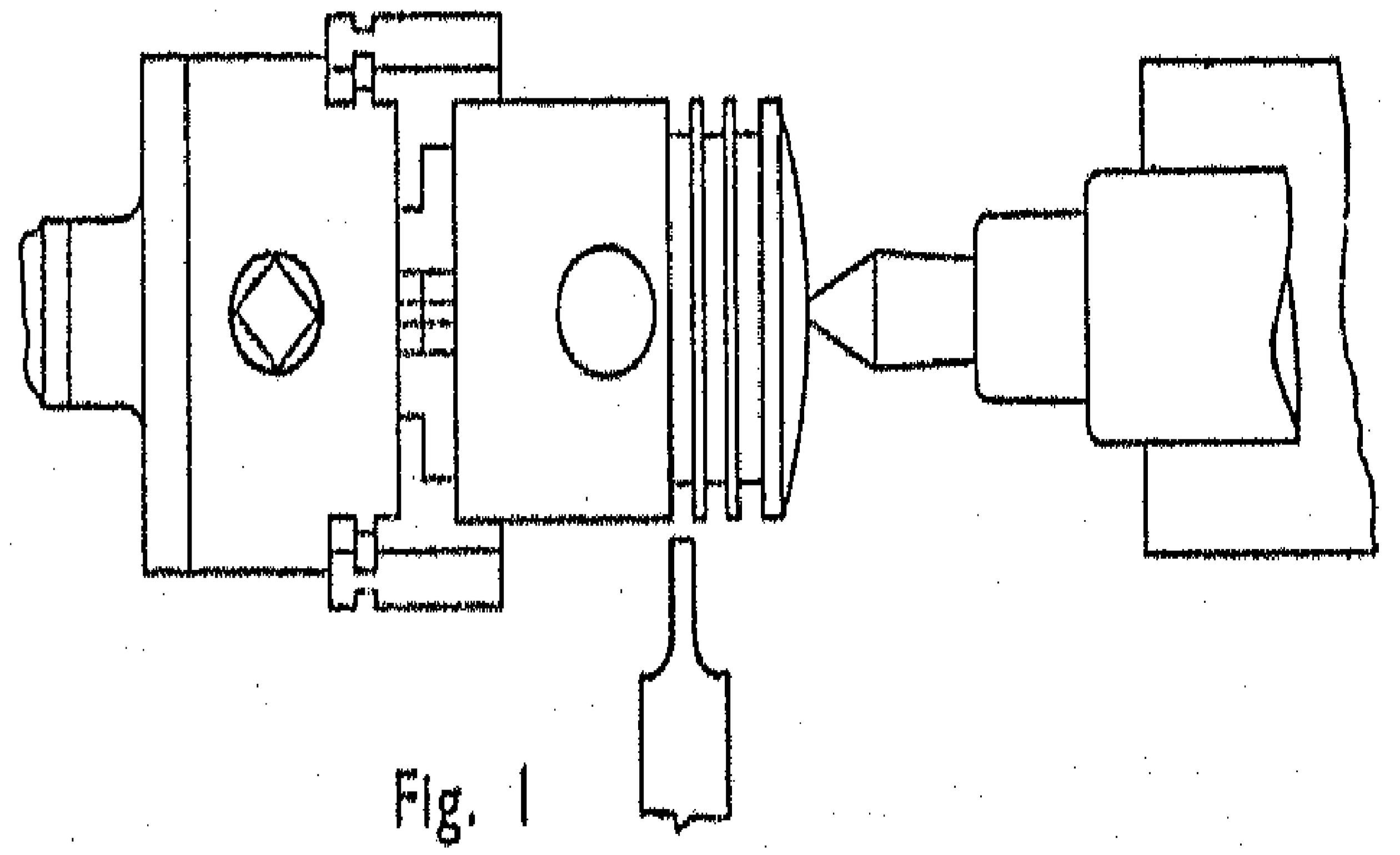


Fig. 1

worn thin in their slots, the slots will also be worn with a shoulder in the sides. Chuck the piston carefully in a three-jaw lathe chuck, using the back centre to support the crown of the piston, and, with a wide parting-tool, turn down the grooves square, and take off just enough metal to leave the sides of the grooves flat and without shoulders. This is shown in Fig. 1. Do not touch the outside of the piston.

To Make New Rings, turn a wood pattern $\frac{1}{4}$ in. larger than the diameter of the cylinder-bore and 4 in. long. It should be cored out to 1 in. in diameter below the cylinder-bore size, so will have core-prints at the end 1 in. less than the cylinder-bore diameter. It is a simple pattern and the foundry will make you a hard cast-iron ring from it.

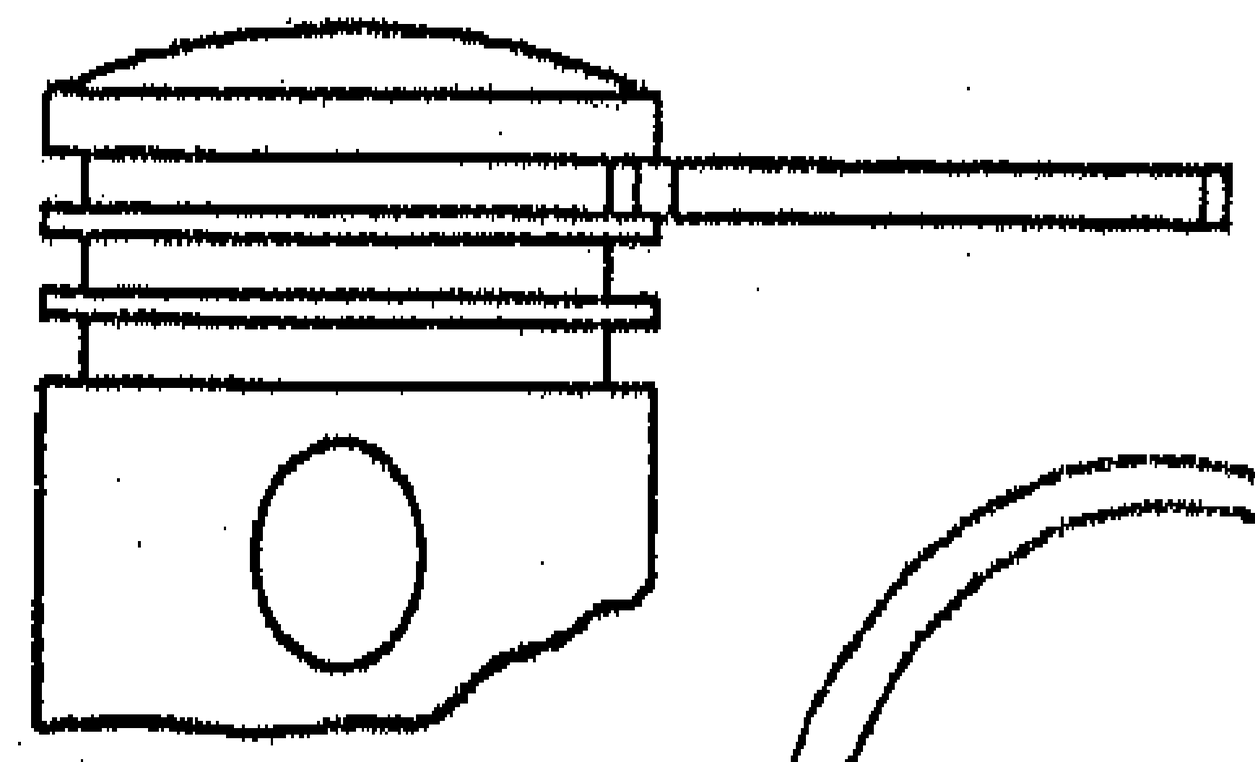


Fig. 2

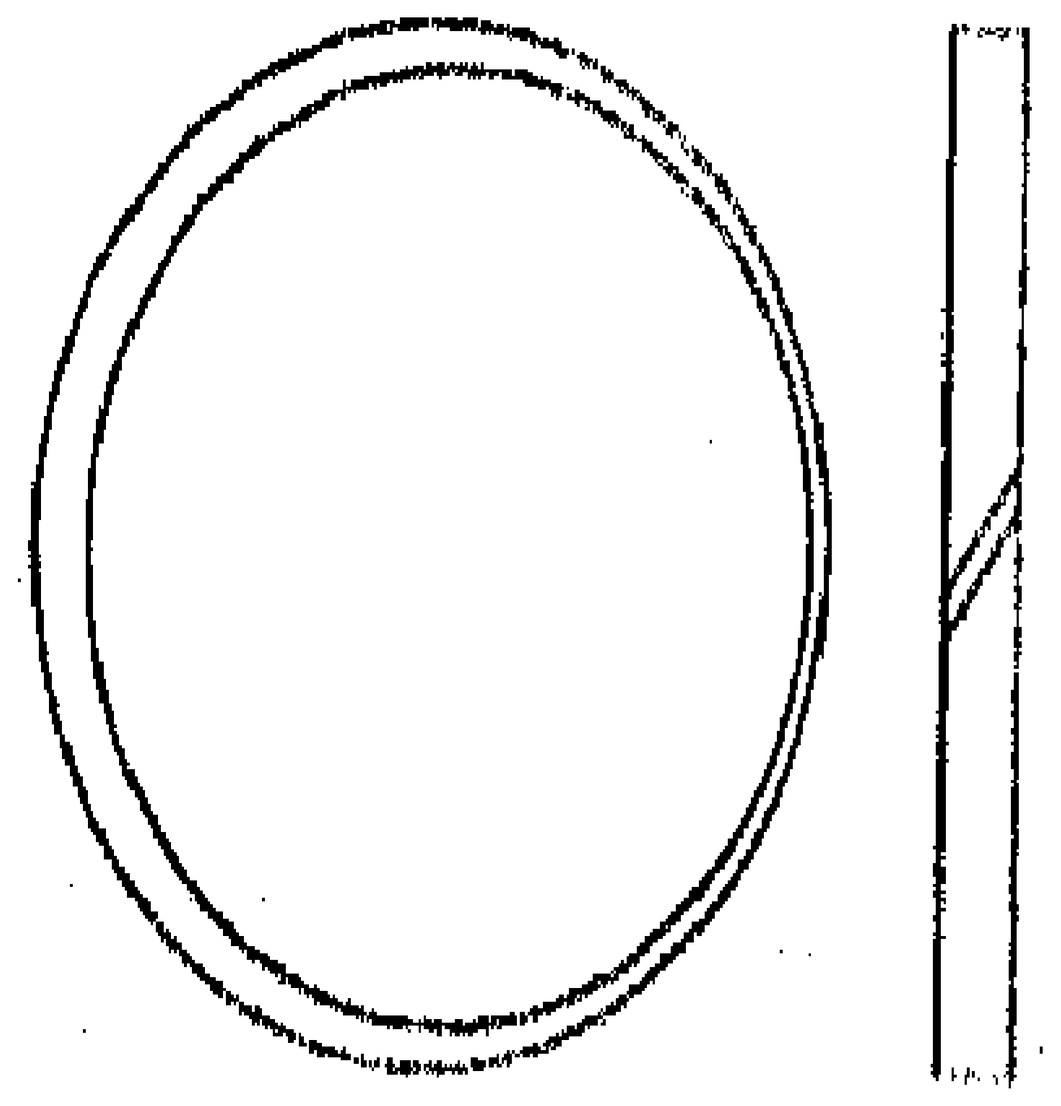


Fig. 3

Place the casting into the three-jaw chuck and bore it out to the inside diameter of the old rings when fully closed. Then pack brass strip under one jaw so as to throw the ring of iron eccentric by the same amount as the old ring. It will be a very small set-over —$\frac{1}{16}$ in. probably. Now turn the outside to the exact diameter of the cylinder-bore, and then remove the packing from under the jaw, keeping the ring in the same place, and close the jaws again. The outside will now run eccentrically and the inside concentrically. The next procedure is to cut off the rings, one after the other, with a parting-tool which should have a square front edge and should taper back each side for clearance—as in the setting for the piston grooves shown in Fig. 1. Since the inside is running concentrically the parting off can be done without injury.

The rings should, before splitting, be rubbed on emery cloth on a surface plate and smoothed on each side and tested by rolling them round the pistons in the ring groove till they will roll perfectly all round, going to the bottom of the groove and touching firmly all round, as shown in Fig. 2. Then the thin part of the ring is cut diagonally with a thin hack-saw as indicated in Fig. 3. The ring should be gripped with the edge just protruding above the vice-jaws—using lead clamps —while cutting the slot. When released, the ring will fly open, and the sawn ends should then be smoothed accurately with a thin warding file.

Try the ring in the cylinder with the joint flush both sides and the cut closed. If the cut closes before the edges of the ring come flush with each other at the slot, it will be necessary to smooth-file a little off one end.

When testing, the ring should be fitted squarely into the cylinder with edges flush. If found to be in order the ring can then be slipped on to the piston and the piston fitted into the cylinder.

The Gudgeon-pin.—Examine the gudgeon-pin when you take the piston off the connecting-rod, and if it is at all shaky, turn a new one out of cast steel bar, which should be very carefully annealed before working and again before the final cut is taken in the lathe.

First reamer out the holes in the gudgeon-pin bosses to ensure they are round and in line, and make the new gudgeon-pin to fit them. It will be a little bigger than the old one, and the bush in the small end of the connecting rod can be reamered out to fit the pin so that when the rod is fitted to the piston the latter will turn just a little stiffly on the new pin. It must not on any account be at all loose.

The Caps.—Take the caps off the two crankshaft main bearings and lift the crank and fly-wheel clear. Wipe the brasses and journals and look for scoring on either. If scored, carefully scrape the bottom brasses and polish the crankshaft journal with a strip of emery cloth held in a wooden holder as in Fig. 4. It is made out of hard wood. A hole the size of the journal is bored through, and it has a butt-hinge screwed on the end. It is then sawn down the centre to form a clamp as shown. Lay the emery cloth in the holder and with oil applied to the journal press the two handles together and pull the tool backwards and forwards round the shaft or crank-pin till the surface is smooth. Measure with a micrometer and if found larger one way than the other, concentrate on the thick side till round to within one and a half thousandths of an inch.

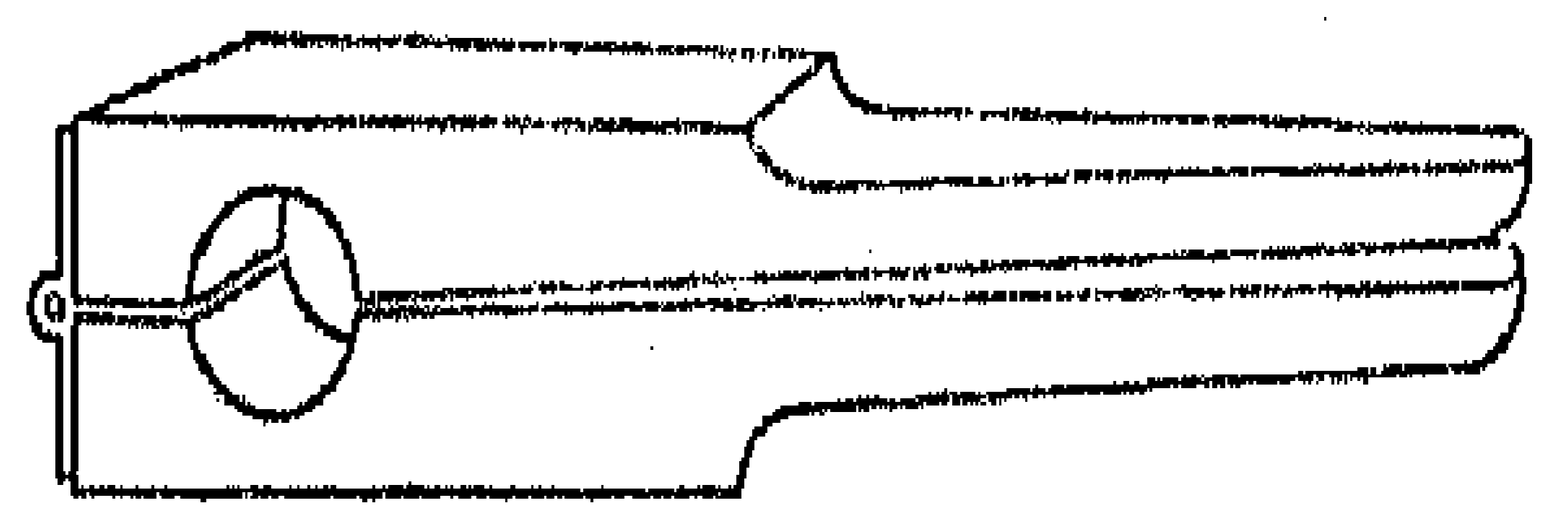


Fig. 4

When the journals are perfectly round and the crank-pin similarly true, apply the bearings. Lay the crankshaft in the bottom bearings, all clean, after having marked the journal with red ochre oil-colour as used by art students, and supplied in tubes. Observe where it touches, and scrape the part very carefully with a scraper (Fig. 5) made out of an old half-round file heated and bent round and carefully tempered to dark straw-colour and ground to the shape shown. The angle is a little more acute than 90° and the bottom is flat (*see* end section).

When the shaft, after repeated trying, and each time wiping the brass and redistributing the red ochre colour on the journal, marks the bearing all over, the job is done for half the bearing. Then place the top half on the lower one and similarly mark it for scraping. The top half may not close on the shaft (or crank-pin, as the case may be) and therefore requires treatment with a file across the face. It should bed down on to the lower brass tightly while being just right on the shaft. A proper marking cannot be had if it rests on the bottom brass before it touches the crank or crankshaft journal. Mark and scrape and clean and mark again, till the shaft or crank-pin marks all over the bearing. Then tighten all up as tight as possible. The crankshaft should be capable of being turned stiffly by hand. If it is easy, take a light cut off the brass face, first seeing which is tight by loosening one bearing and trying; but tightening up between tests. If it is still tight you know it is the other one which is loose. Slack off the first and tighten the other. It will be found not to close tight on the crank. Take a light cut over the face with a very smooth file, and screw down tightly again.

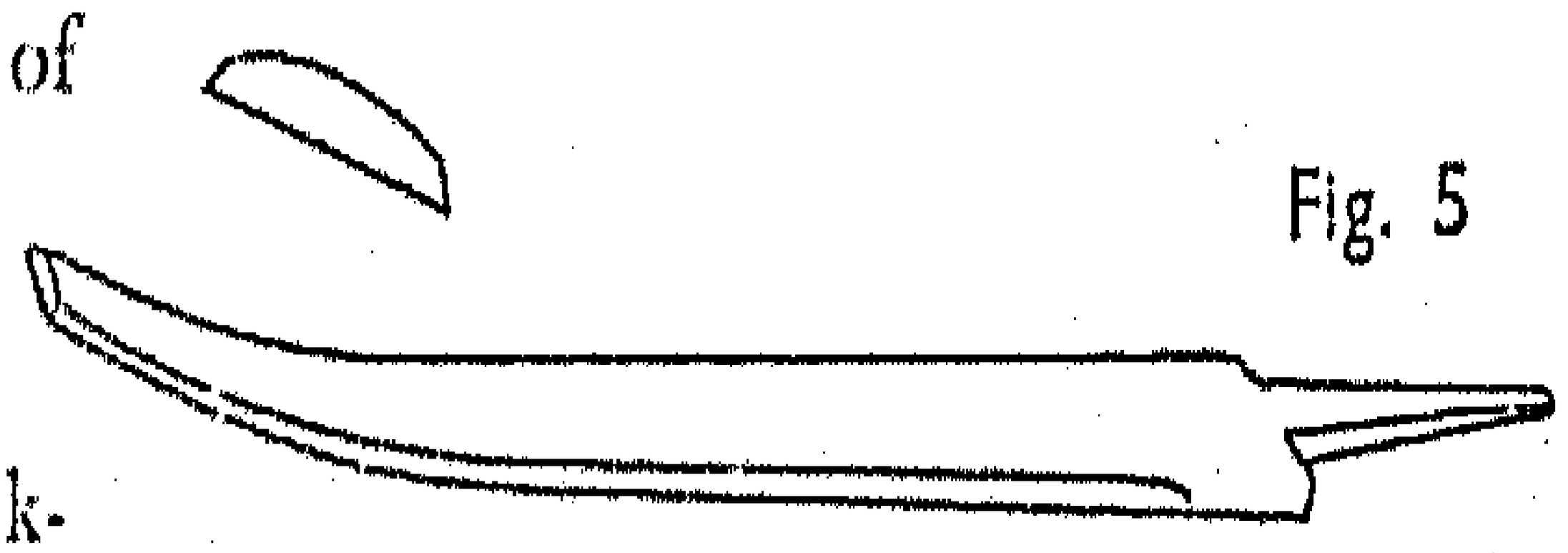


Fig. 5

Examining the Valves.—Remove the cotter and the spring and withdraw the valve. If the seat and the head of the valve are badly pitted or the valve shows black at any part of its face, it must be ground in. Scrape the valve and seat and rub with coarse emery, treating the valve stem endways. Clean the valve-stem guide and oil it. Then make a spring of tough, springy wire to surround the upper portion of the valve guide and the valve stem, and have it of such a length that it will lift the valve from its seat as indicated in Fig. 6. Smear the valve-face with a coarse valve-grinding compound, and work the valve in an oscillating manner half a turn at a time backwards and forwards with a screwdriver. The spring will lift the valve when pressure is taken off the screwdriver. The valve should be allowed to come off the seat constantly, and be pressed down in another position—say, half a turn round. Continue the grinding till a light grey ring of even width—about $\frac{1}{8}$ in. wide—is ground round the valve-edge and valve-seat. Then remove all traces of emery with petrol, oil the valve stem with thick oil, and replace with spring and cotter.

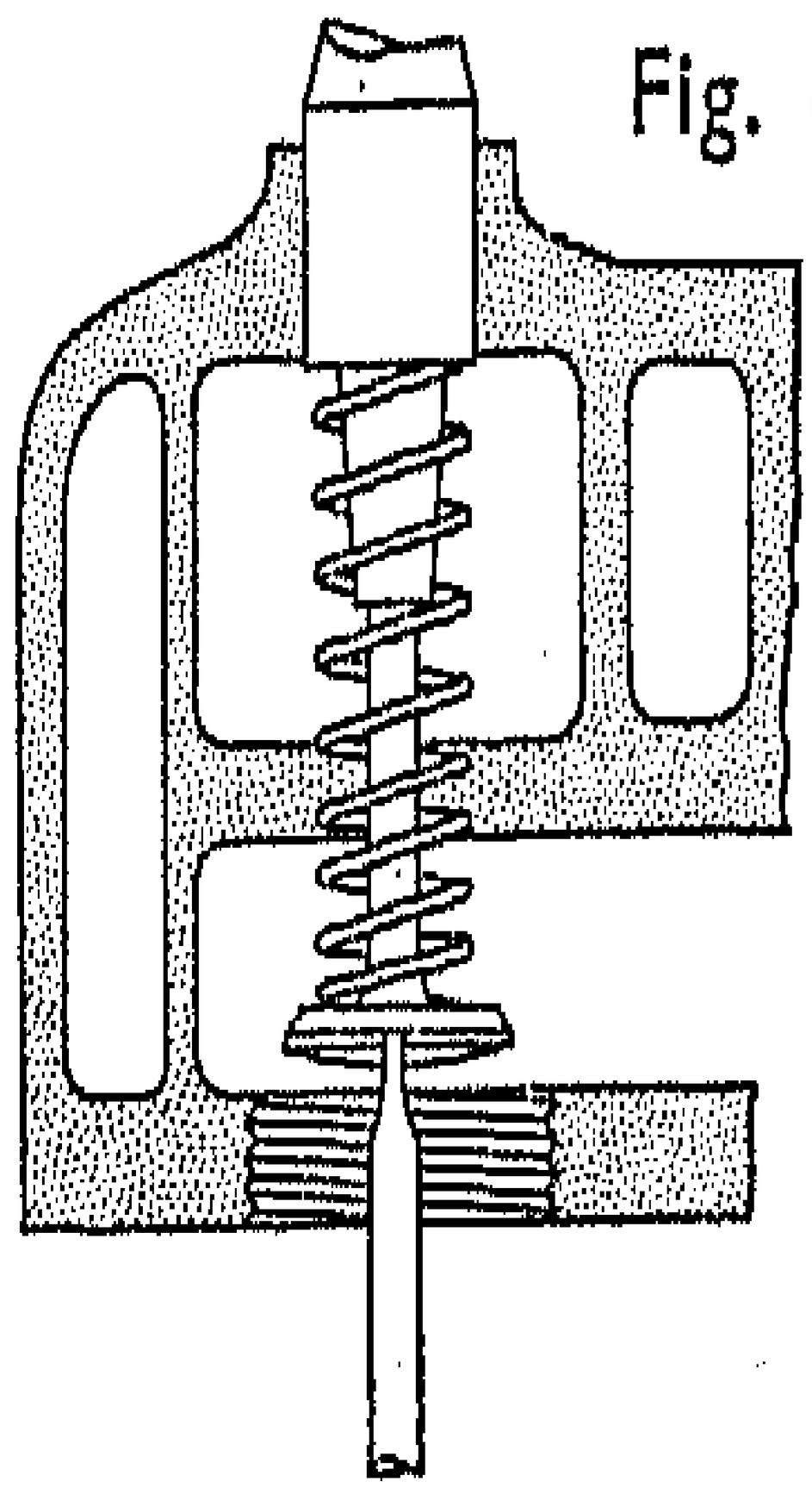


Fig. 6

The Rocker Lever which operates the valve has its adjustment at the end, where it lifts the valve stem; and the adjustment should be made so that when the engine is warm, the valve seated, and the roller at the end of the rocker in contact with the low side of the cam, there is a clearance between the abutment screw and the valve stem of three thousands of an inch, as indicated in Fig. 7.

In some gas engines there is a timing valve which opens the combustion chamber to the hot-tube chamber. This valve works under bad conditions and sometimes hangs up, entirely preventing the engine starting or running. It gets gummed up with solidified oil. Ease it regularly with petrol and then use paraffin, and then, when dry, apply only the finest light motor-oil. It only requires a very little, and a pint would last a year. But it should be kept clean and always lubricated. Sometimes the helical toothed two-to-one gear has too much back-lash and the engine makes a lot of noise. The bracket which carries the horizontal shaft to the valve gear may be lifted very slightly to bring the big wheel on the camshaft a little nearer the half-size wheel on the crankshaft. It is usually dowelled for position and held by a couple of studs. Withdraw the bracket, knock out the dowel, draw the stud-holes with a round file ($\frac{1}{32}$ or $\frac{1}{16}$ in.) and bolt the bracket back with the stud units and tap with a hammer up to nearer the crankshaft wheel. Tighten up and run the engine, and if it runs silently, drill a new dowel-hole and drive a new dowel-pin to locate it.

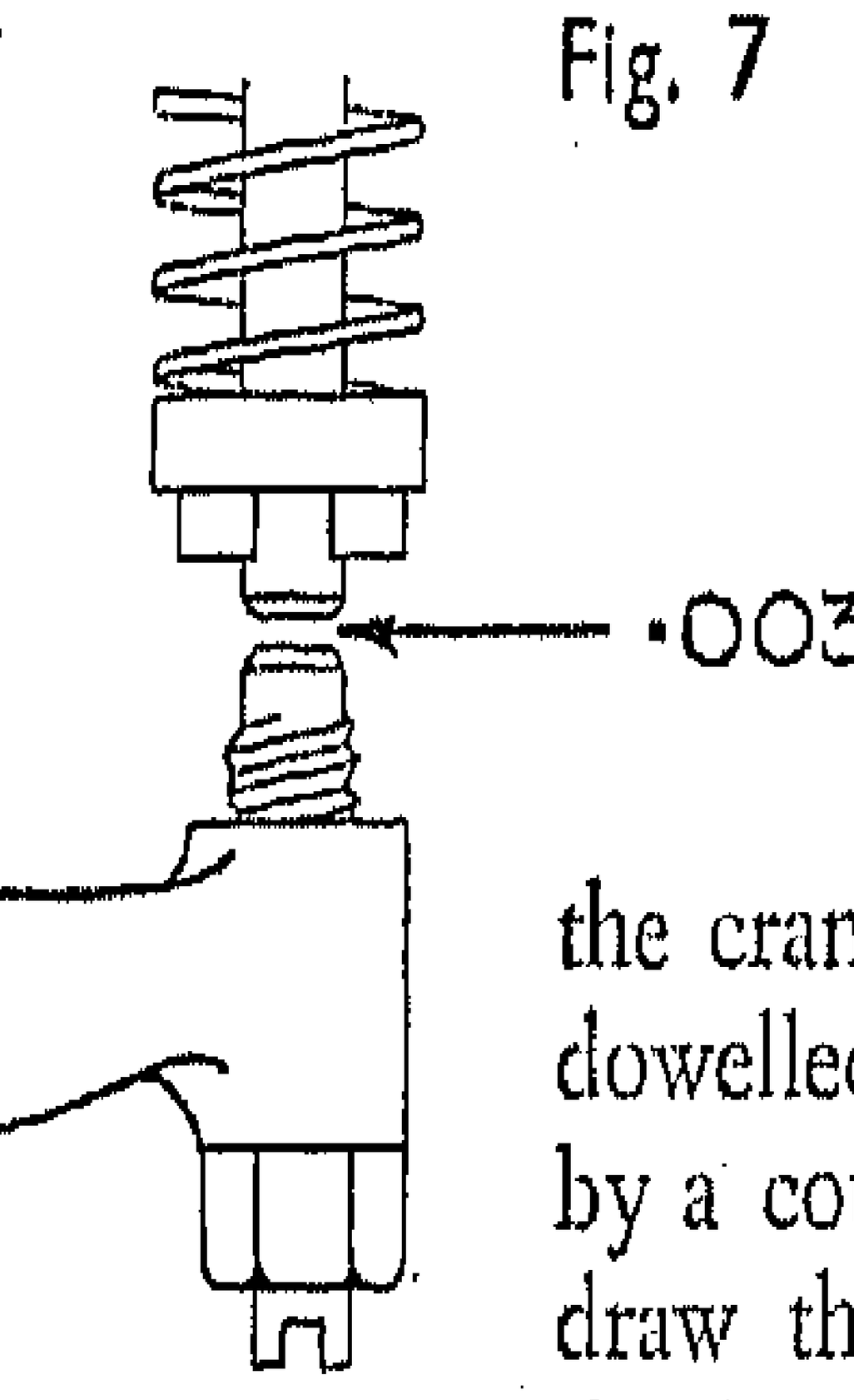


Fig. 7

Look at the Rubber Gas-bag.—If it is perished get a new one. A new bag or diaphragm is worth while, for the gas engine, without the governing effect of the gas bag, will run jerkily, waste gas and make your whole gas-supply jumpy.

See that oil can actually get to the big end bearing while the engine is running.

Swill out the water-jacket with hot soda water left in for a day (or longer if possible) and clear the water-pipes and tank entry and exit. Also send a scraper brush along and up the exhaust pipe. Dismantle the silencer and scrape clear of carbon and see that nothing chokes its exit. If the engine exhausts into a pit, make sure that water can get away easily.

MOTOR-CAR ADJUSTMENTS

In these days, when motoring is common both for business and pleasure, it behoves the owner to know something about the mechanism of a car in order that he may be in a position to execute certain repairs without the necessity of taking the car to a garage every time a little trouble is experienced. By carrying out one's own repairs, not only is a great deal of time often saved, but the running costs of the car are reduced to a minimum.

A motor-car may be said to be made up of eight distinct parts, excluding the body, which may be summarised as follows:

1. The engine, or power generator.
2. The clutch for connecting the power unit to the transmission.
3. The gearbox, forming part of the transmission.
4. The propeller shaft and rear axle for transmitting power to the road wheels.
5. The brakes.
6. The front axle and steering gear.
7. The electric installation.
8. The frame, including the springs.

The following paragraphs contain a brief description of these parts, how, and for what they function.

The power of the engine is obtained by the explosion and the resultant expansion of a gas in the cylinders of the engine. This "mixture" is produced by means of a carburettor, and exploded by an electric spark generated either by a magneto or a battery and coil. A definite sequence of events occurs in the engine to produce this power; in most engines it is that known as the "Otto" principle or cycle. This cycle is comprised of four strokes of the piston, namely, (1) The suction or induction stroke, (2) the compression, (3) the explosion or ignition, and (4) the exhaust, respectively. So for every two revolutions of the crankshaft we only get one power-stroke. These strokes are shown diagrammatically in Fig. 1.

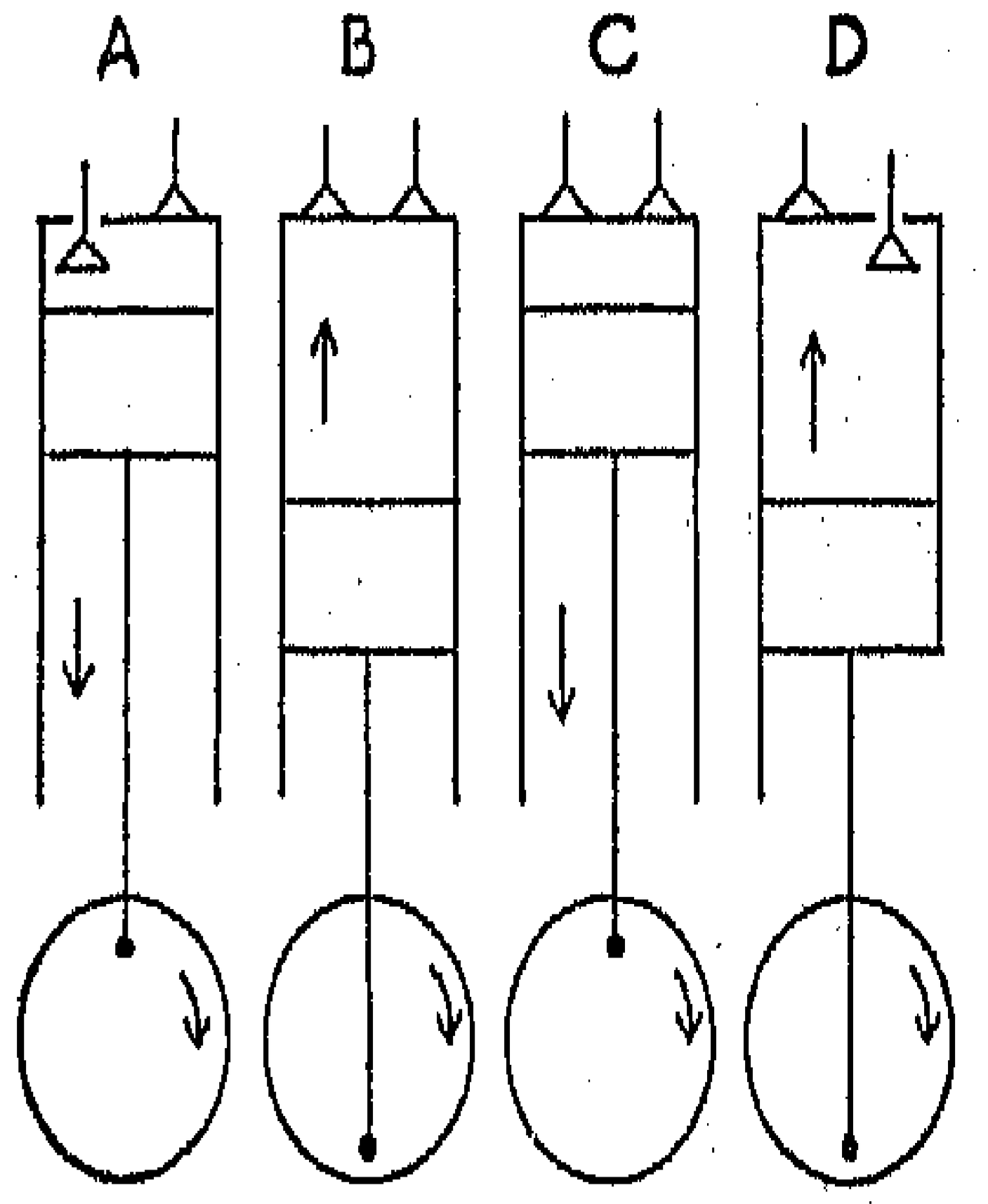


Fig. 1

As the piston starts to move down the cylinder on the suction stroke (A) a valve, called the inlet valve, is opened by means of a cam, allowing the gas mixture to be sucked into the cylinder from the carburettor. This valve shuts when the piston gets to the end of the stroke. In general practice, the inlet valve actually closes when the piston starts to go up on its next stroke. The next stroke (B) is the compression stroke and is upwards, and, as its name suggests, the piston compresses the gas into a very small space ready to be fired. At the end of this last upward stroke a spark occurs in the compression space at the top of the cylinder, exploding the gas. The explosion and the resultant expansion of the gas forces the piston down as at C, thus creating the force or power to turn the crankshaft. Nearly at the end

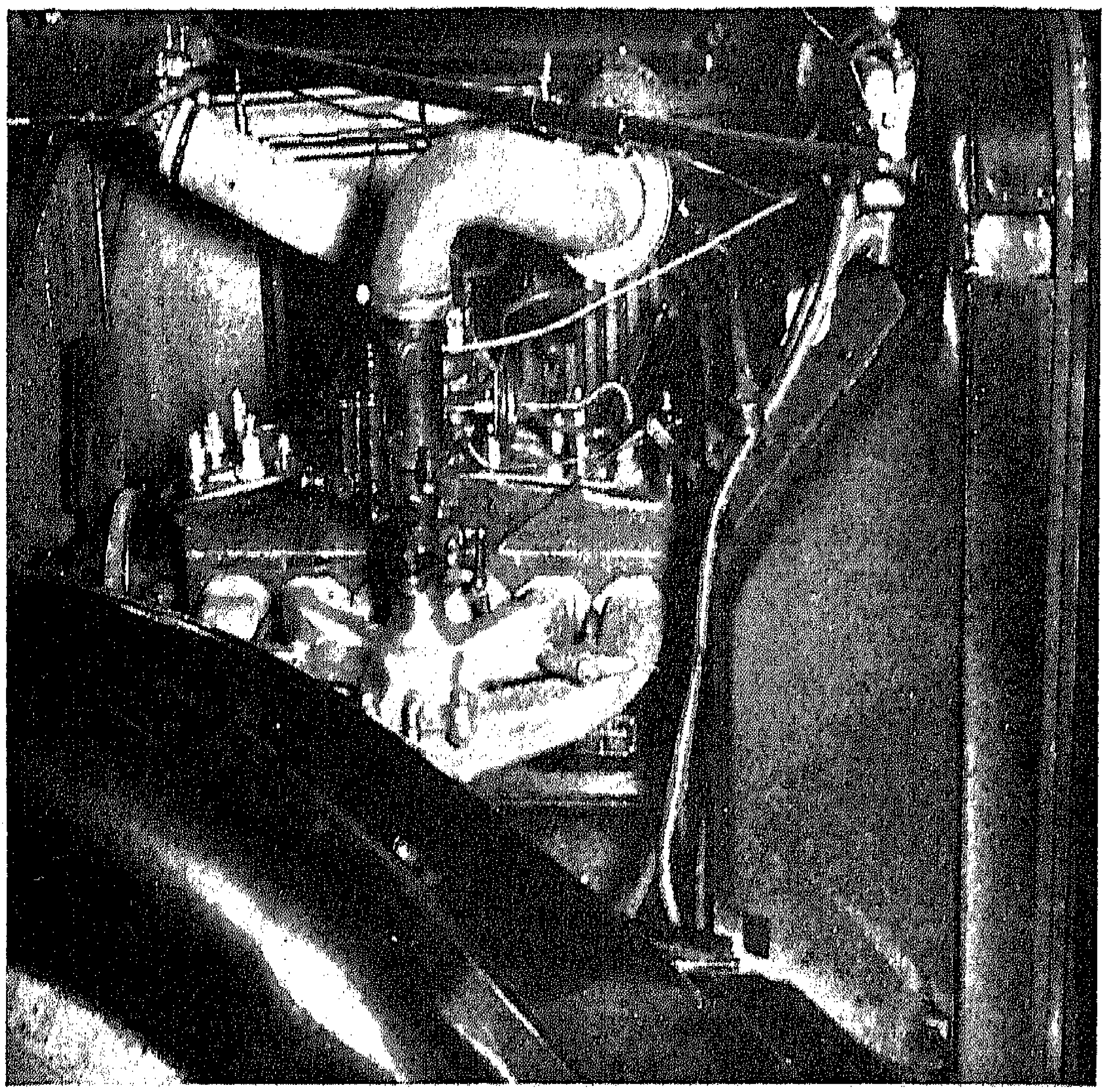


Fig. 2

of the power-stroke, a valve, called an exhaust valve, opens by means of a cam, thus allowing the exploded gas and the gas which is still expanding to escape. On the upward or exhaust stroke (D) the remainder of the exploded gas is forced out through an exhaust port, exhaust pipe, and silencer, into the open air. At the end of this stroke the exhaust valve closes and the sequence of the cycle is repeated, and so on.

As can be readily understood, the one explosion has not only to give power to propel the car but also has to overcome the resistance of the other three strokes. To assist in this work a flywheel is fitted to the crankshaft, which, after the explosion has taken place, stores enough energy in it to carry the crankshaft round through the other three strokes.

The cranks, valve openings, and the spark are so arranged that all cylinders fire or create power during the two revolutions of the crankshaft, so the more cylinders there are, the more even the force or torque, and the more continuous the turning movement imparted to the crankshaft.

The explosion naturally generates excessive heat and, to keep the metal parts from burning or seizing up through expansion, the moving parts have to be lubricated with oil, generally supplied by means of an oil pump driven by the engine, although in some instances splash lubrication is employed. The cylinders are kept cool with the aid of water supplied from a radiator which circulates through a jacket surrounding the cylinders.

The Radiator is situated in the front of the car, and is designed not only to cool the water, but to keep it at its correct temperature. This is necessary because a petrol engine being a heat engine is most efficient when kept hot. One of two methods is adopted to circulate the water round the cylinder-jacket and the radiator. That known as the thermosyphon principle derives its circulating effect from the physical fact that the heated water rises to the top, while the cold sinks, and in so doing causes the water to circulate. This method is the one used on modern petrol-driven car engines. A pipe connects the top of the cylinder-jacket or head to the top of the radiator (as illustrated in Fig. 2), and a similar one from the bottom of the radiator connects to the bottom of the cylinder-jacket. Large-bore pipes are used to allow free movement of the water. As the water absorbs the heat from the top of the cylinder it rises up the pipe to the top of the radiator, where, on being cooled, it descends to the bottom, and so back to the water-jacket. The whole mass of water is soon heated up and is kept at a more or less uniform heat.

In the other method, a circulator or pump, driven by the engine, is installed in the water-system to force the water round, drawing it from the cylinder-top through the radiator, where it is cooled, and forcing the cooled water into the bottom of the water-jacket and so to the cylinder-top. In this arrangement smaller pipes can be used.

A fan, driven by the engine, is sometimes used with either of the above-mentioned systems to draw air through the radiator apertures, to assist in cooling the water.

The Carburettor.—Mention has been made of the carburettor, which might be termed the heart of the engine. Its function is to convert the liquid petrol into a mixture of petrol vapour and air in suitable proportions to produce a highly explosive mixture. The carburettor is in direct communication, through an induction or inlet pipe, with all the inlet valves of the engine. The principle upon which the carburettor works is based upon that of a garden sprayer, where air at high velocity is drawn or forced past or over a tube having a small outlet or hole in the top, the tube being full of liquid. The liquid is drawn out in the form of a very fine spray or vapour.

In the interior of the carburettor, the tube mentioned above is represented by a small device called a jet. The petrol is supplied to the jet through a float-chamber which forms part of the carburettor. An automatic valve, operated by a float in this chamber, controls the height of petrol in the jet.

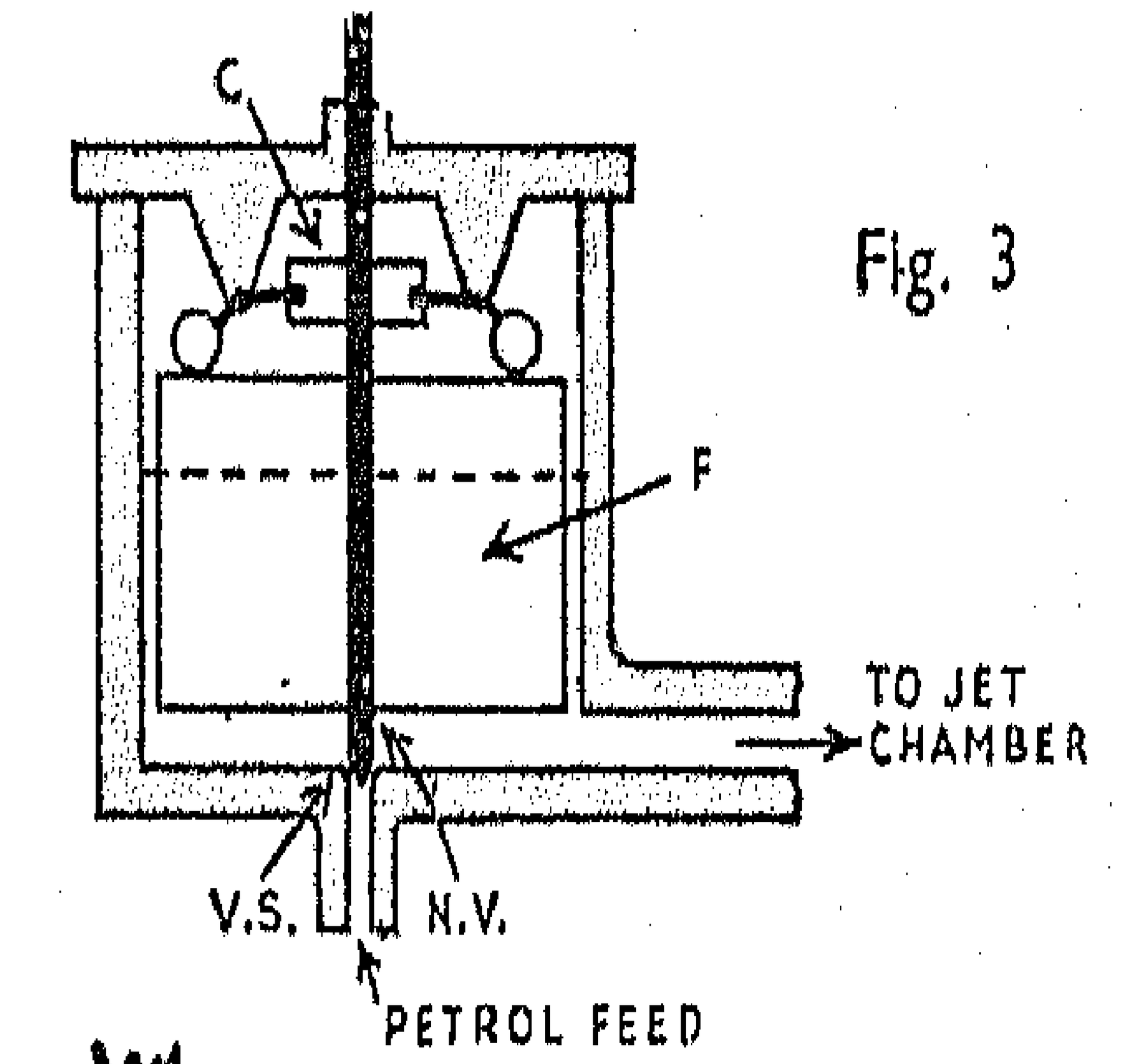
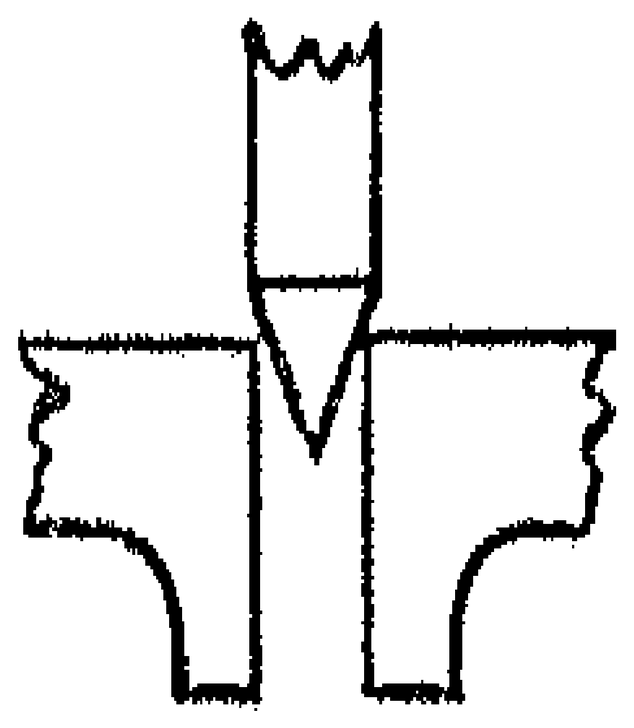


Fig. 3



The automatic device is simple and effective and consists of a float (F, Fig. 3), needle valve (NV), and valve seating (VS). Resting on the float are the weighted ends of two hinged levers, the other ends fitting loosely into a collar (C), which is fixed to the needle-valve spindle. The other end of the spindle is accurately pointed and fits into a corresponding chamfered hole through which the petrol is fed.

The action of the valve is quite simple, for when the petrol is drawn from the float-chamber by the action of the engine, the float naturally goes down, the weighted ends of the levers fall while the opposite ends rise, and in so doing lift the needle off its seating, allowing